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[NOTICE.]

Annual Meeting, Michigan Gas Association.

MICHIGAN GAS ASSOCIATION,
OFFICE OF THE PRESIDENT, SAGINAW, MICH.,
November 7th, 1903.

To the Fraternity: The next meeting of the Michigan Gas Association will be held in Saginaw, February 17th and 18th, 1904, and already an excellent list of papers has been promised.

The past meetings of the Association have been successful, profitable and enjoyable, and it is desired, if possible, to make the meeting of February next the most successful one held.

An earnest effort will be made to have all papers that are to be presented, printed in advance and bound together in a volume to be distributed among the members present at the meeting. This has not always been done in the past, owing to the fact that some of the papers promised were delayed and not forwarded to the Secretary, Mr. Douglass, until a day or so before the meeting. It is to be hoped, therefore, that the members who have promised papers will not delay in getting them prepared and forwarded to Mr. Douglass, certainly by January 15th, next.

Personally, I feel that this Association of ours is an organization of which we may well be proud. I think, however, we have not as yet reached the point of excellence obtainable, and that we can, if we all pull together, increase our membership, the standard of our papers and the fraternal feeling existing for each other. Fraternally yours,

B. C. COBB, President.

BRIEFLY TOLD.

DEATH OF COL. WM. A. STEDMAN.—With much sorrow we report the death of another veteran gas man, one whose name 25 years ago was a household word among those identified with the gas industry of America. Well liked by his contemporaries, death will not obliterate for many years from the roll of America's gas engineers the name of Colonel William A. Stedman, who passed away, at his home in Framingham, Mass., the morning of Sunday, November 8th. His death was the result of an apoplectic shock, and its suddenness was startling. He was born in Newport, Rhode Island, the spring of 1836, and acquired his education and first business training in that city. In 1862 he assumed an important position with the Newport Gas Light Company, and shortly thereafter became its Superintendent and Manager. In 1887 he joined his fortunes with those of the American Electric Manufacturing Company, of New York—resigning from the service of the Newport Company—but the venture was not a successful one, chiefly owing to the peculiar manipulations of the man, who was mainly responsible for the formation of the concern. Returning to the gas business he became Engineer and Superintendent to the Laclede Gas Light Company, of St. Louis, Mo. He subsequently resigned from its service to accept the position of Vice-President and General Manager of the Flatbush (Long Island) Gas Company, which flourishing institution is virtually controlled by the Brooklyn Union Gas Company. There he remained until July 1st of this year, when he resigned

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to retire from active business cares. On his resignation his associates and employees presented him with a watch chain and charm, and a set of cuff buttons handsomely mounted with diamonds. It is worthy of note to relate that his speech of acceptance and acknowledgment of the gifts to the donors was: "This is my first present in life in this respect," and then wept like a child. On leaving Flatbush he purchased a country home in Framingham, where, with his wife, his declining years were to be spent. He is survived by his widow, two sons and one daughter. The funeral services were held in Newport last Wednesday, and the ceremonies were of the private order. In public matters connected with the gas industry he had been very prominent. He was a charter member of the New England Association of Gas Engineers, and its Fourth President; was a member of the American Gas Light Association since 1877, and its Fifth President; was, if we mistake not, an original member of the Society of Gas Lighting, and was for a long time prominent in the affairs of the Guild of Gas Managers. He served his country during the Civil War as a member of the First Rhode Island Volunteers, resigning therefrom with the title of First Lieutenant. At a later period in his life he served as Colonel of the famous military organization known as the Newport Artillery. Of commanding physique, possessing the best of training (mental, moral and physical), Colonel Stedman will long be remembered as a man whose individuality was markedly distinct.

NOTES——

COLONEL STEDMAN'S successor as General Manager of the Flatbush Gas Company is Mr. Henry E. McGowan; and Mr. E. R. Ellsworth has been promoted to the position of Superintendent.

"W. O.," writing from Detroit under date of the 12th inst., says that the proprietors of the Lansing (Mich.) Gas Company have authorized the placing of an addition to the retort house equipment that will be equal to doubling the generating capacity of the plant. It has also been agreed upon to put down a high pressure main line for the supply to North Lansing, a thriving suburban town.

MR. T. L. BELLINGRATH has succeeded Mr. J. E. Montgomery as General Manager for the Talladega (Ala.) Light and Water Commission.

AN ordinance has been introduced in the City Council, of Vancouver, Ore., which authorizes J. E. Morson, as Trustee, and his assigns, the right to construct gas works in the city and use the public streets for the purpose of laying mains. It provides that the franchise shall continue 50 years and that work shall commence within 6 months after they shall have secured 300 contracts for the supply of residents, and the works then shall be completed and in operation within 9 months. If after the expiration of the first 10 years the city shall have attained a population of 25,000, then 1 per cent. of the income of the Company shall be paid to the city. The ordinance was referred to the Judiciary Committee and City Attorney Stapleton.

Progress of Machinery Installation at the World's Fair.

The foundations for the large Westinghouse engines being installed in the Machinery Building at the St. Louis Fair Grounds are completed, and a 40 ton electric crane is now at work depositing the various parts of the engines in their proper places. The foundations for the Allis-Chalmers 5,000-horse power engine which is to be installed are now being prepared by the Department of Machinery. The crane, which will be installed for the erection of the Allis-Chalmers engine and its generator and accessories, is being built by the Shaw Electric Crane Company, of Muskegon, Mich. The crane will be of 60 tons capacity and electrically operated; 80 foot span, two trolleys, each of 30 tons capacity, and one of these trolleys is also provided with a 5-ton auxiliary hoist.

The heaviest individual piece in the Allis-Chalmers Manhattan type engine and 3,500-kw. Bullock generator, which it drives, weighs 84 tons. There are now something like 15 foundations for large engines either completed or in progress in the western half of Machinery Hall. Two of the engines are from Europe, one being a 1,000-horse power tandem compound steam engine from Mülhouse, Germany, and the other a 1,500-horse power vertical triple expansion, high speed steam engine from St. Denis, near Paris, France. The former unit is directly coupled to a 700-kw. generator, built at Belfort, France, and the latter is coupled to a 1,100-kw. generator built in Paris. These two units serve the arc or patrol lighting system. The largest individual engine unit in the Intramural power plant is a 1,750-horse power gas engine from the firm of A. Borsig, Berlin, Germany. The total power generated in Machinery Hall is something over 45,000-horse power.

Different Gases in Gas Engines.

[A Lecture delivered at the 31st meeting of the American Gas Light Association (Detroit, Oct. 21, 22 and 23, 1903), by PROF. ALFRED H. WHITE, of the University of Michigan.]

The art of making large gas engines has made enormous strides in the last few years. Engines of 500-horse power are no longer considered large, and engines of 1,500-horse power are being built, but we hear very little of large gas engines built for illuminating gas. Almost all of them are built for fuel gas and many of them for blast furnace gas. The discovery that blast furnace gas could be profitably used in gas engines has raised quite a furor in the engineering press because of the vast possibilities of waste power that may thus be made useful. It is certainly startling to hear that one of our large 500-ton blast furnaces can, after using all the gas it needs for all its own uses, develop and sell nearly 15,000-horse power. On this basis, if all of the blast furnaces of the United States were equipped with gas engine plants, there would be 1½ million horse power generated over and above the needs of the furnaces for all purposes.

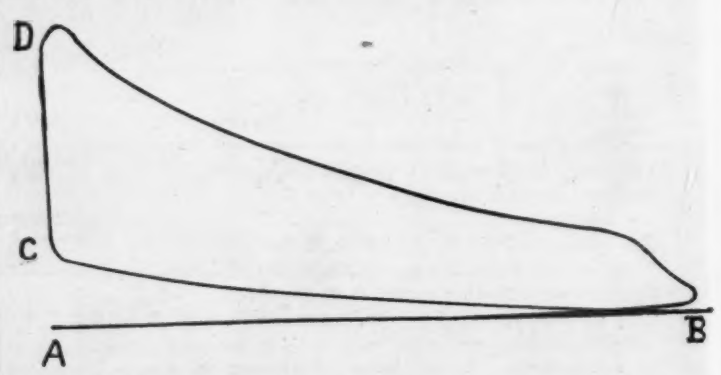
Blast furnace gas is so poor that it will scarcely burn in the open air, and ten years ago the proposal to use it in gas engines was received with scorn. But to-day we find that, out of 100 heat units supplied to the engine, as many and often more are transformed into useful work in the case of engines fed with blast furnace gas than with engines using lighting gas, and one of the builders of large gas engines has stated as his ideal gas for gas engine use one which is, to all intents and purposes, the once despised blast furnace gas.

The earlier gas engines were all built for illuminating gas, and the adoption of the lower grade power gases has been a growth of recent years. What is it that has caused such a change of sentiment among some at least of the gas engine builders?

It is to this phase of the subject (the influence of the kind of gas used) that I propose to devote the time allotted to me this morning. Its consideration involves some study of the phenomena which take place in the engine cylinder.

The cylinder is the most important part of the engine because there the power is developed and there the most serious sources of loss reside. The operation is apparently simple. A combustible gas is mixed with air in proper proportion and ignited. The gas rapidly burns (explodes) to carbon dioxide and water, and the heat set free expands the gases which do work on the piston; but the first step in remedying a fault is to find out where and exactly how great it is, and when we try to analyze the various sources of gain or loss in the cylinder we find ourselves possessed of very little certain information as to what goes on there beyond the fact that a mixture of gas and air is drawn in, that combination takes place, and that later the products of combustion are ejected after doing a certain amount of work.

It was the advent of the Otto engine in 1876 which brought the gas engine into the realm of commercial practicability. The feature of value in this engine was the compression of the air and gas charge previous to its explosion. To effect this Otto boldly cut loose from all traditions, which were to give the piston an impulse every time it went forward, and gave the piston an impulse only on every other forward stroke, or one impulse for every four strokes. An examination of this sketch of an indicator card from an Otto engine will serve to recall the cycle.



The piston, moving from *A* to *B*, draws in a charge of gas and air, compressing it at the return stroke to pressure, shown at *C*. When the piston is on its dead point the charge is exploded, and the rise of pressure is almost instantaneous to *D*. The piston then moves forward under the influence of the compressed gases, the pressure falling off as

the piston moves until near the end of its travel, the exhaust valve opens and the products of combustion are pushed out by the return stroke of the piston. The efficiency in an engine of this type, as deduced theoretically, may be shown to depend almost entirely upon the amount of compression to which the gases are subjected before explosion. The higher the compression temperature the more efficient the engine. Practice has shown results according fairly well with the theory in this respect, and the natural result has been that manufacturers have kept increasing the compression temperatures until they have been forced to call a halt because of limitations set upon them by the nature of the gas used.

When a gas is compressed, say to one-fifth of its volume in as small a fraction of a second, the energy required to effect its compression is almost entirely converted into heat which raises the temperature of the gas. The greater and more rapid the compression the hotter does the gas become, and it is easy in practice to heat a charge of gas and air so much that it will prematurely explode in the cylinder. The danger of this is greater in large engines than in small because of the relatively smaller cooling effect of the walls in a large engine. The strains due to premature explosion are also more serious in large engines. Of all the gases, hydrogen is the one which most easily explodes under these conditions, and hydrogen is an important constituent of most of our commercial gases.

This danger of premature explosion puts an effective bar on too great increase of compression before explosion. It is because of the possibility of safely compressing blast furnace gas more than other gases that this gas has become such a favorite with some engineers. Blast furnace gas will carry about 30 per cent. carbon monoxide, 3 per cent. hydrogen and the remainder carbon dioxide and nitrogen. This gas mixed with a favorable proportion of air will hardly burn, much less explode, with the promptness and certainty necessary in a high speed gas engine. It is necessary to heat it by compression to make it explode and compression may be safely carried much farther with it than with the gas containing much hydrogen. For equal amounts of compression blast furnace gas will show a much lower efficiency than a rich gas, but with greater compression an efficiency almost equal to and sometimes better than its old-time superior. Let us see if we can find any explanation for this.

It will be of interest to compare the theoretical flame temperatures and the volumes of the products of combustion at the elevated temperatures. I do not wish to take your time with the details of the somewhat wearisome calculations necessary for this, but have prepared them for printing in your "Proceedings" as an appendix to this lecture. Let us take for comparison the carburetted water gas, blue water gas and blast furnace gas, details of which are given in the appendix, and determine what pressures would be exerted by the explosion of each with the theoretical amount of air. It will be convenient to assume an engine with a cylinder containing a charge of 1 cubic foot. The piston is not supposed to move during explosion which takes place at constant volume. We may calculate the theoretical temperature of combustion and from that the theoretical pressure that would be produced.

The theoretical temperatures may readily be calculated if we know the composition of the fuel, the amount of air used, and the specific heats of the products of combustion. It is in connection with these specific heats that the greatest uncertainty arises. The specific heats of the products of combustion, as obtained by Regnault from his experiments at ordinary temperatures, gave preposterously high temperatures as theoretically possible. In 1883 Mallard and Le Chatelier, by their classic researches on the explosion of gasses in closed vessels, obtained experimental data on the specific heats of these combustion gases at higher temperatures, and showed conclusively that the specific heats rise rapidly with increase in temperature. The principle of this work has been confirmed by others, although there is considerable divergence in the numerical results obtained by different experimenters. In the absence of any authoritative revision of their work, however, the Le Chatelier specific heats are probably those more frequently used by engineers. Unfortunately, the knowledge of them has remained almost exclusively in the hands of those accustomed to using the metric units and to reading French and German. Tables of these specific heats which I have calculated from the original data are given in the appendix to this paper. In the calculation of theoretical specific heats we assume that combustion is complete and instantaneous, that there is no dissociation of the products of combustion, and that all of the heat produced is used in raising the temperature of the gases remaining after combustion. For this calculation we must know the amount of heat developed by the combustion of a given quantity of gas, and the amount and specific heat of each constituent in the products of combustion. It is customary to deal with volumes and not with weights of gases, and on that account it is much more convenient to use specific heats by *volume* and not by *weight*. The use of these volumetric specific heats also obviates largely the need of laborious calculations from the metric to the English units. The method of calculation is given in full in the appendix.

From the temperatures thus obtained, and a knowledge of the amount of air required for complete combustion, it is possible to calculate the pressures that would be developed by the three gases under like conditions. When combustion of these gases takes place there is always a diminution in volume due to chemical combination. This may most conveniently be allowed for by assuming that the heat acts upon the gases of combustion at the volume which they would have when cooled. As this volume is less than 1 cubic foot and the gases still fill the 1 cubic foot cylinder, it follows that they are under reduced pressure. What this is may be calculated from the ratio of the volumes under constant pressures of the gases before and after explosion. In carburetted water gas, for example, the relative volumes are 6.90 before explosion and 6.68 after, from which it follows that the combustion gases in the cubic foot cylinder are under a pressure of $\frac{6.68}{6.90} = .967$ atmospheres. This is given in the table as "Initial Pressure Products of Combustion." The formula for explosion pressure is $\frac{p}{1} = \frac{t}{1}$, where p = initial pressure; p1 = explosion pressure; t = initial temperature absolute, and t1 = explosion temperature absolute. In the case of the carburetted water gas previously referred to, $\frac{.967}{p1} = \frac{290}{2,463}$. The explosion pressure p1 is then 8.02 atmospheres. We may now tabulate the data for the three gases, leaving further details of calculations to the appendix.

Comparison of Gases.

	Carburetted Water Gas.	Blue Water Gas.	Blast Furnace Gas.
Net heating value, B.T.U. per cubic foot.	673	278	111
Vol. air required for 1 cubic foot gas...	5.90	2.21	.792
Vol. products of comb. from 1 cubic foot gas.....	6.68	2.75	1.627
Vol. of charge in cubic foot. Gas.....	.145	.311	.558
Vol. of charge in cubic foot. Air.....	.855	.689	.442
Temp. of explosion at constant pressure, degrees C.....	2,190	2,145	1,690
Absolute temp.....	2,460	2,418	1,963
Initial pressure products of comb. in atmospheres	.965	.855	908
Pressure of explosion in atmospheres....	8.02	7.13	6.15
Relative volume of gas in charge, carb. water gas being 1.....	1	2.01	3.85

The pressure generated by the blast furnace gas is considerably the lowest. But remembering the advantages to be gained by compression, it will be worth while to consider the results given by this gas if the charge is compressed before explosion to, for example, 10 atmospheres. The formula for the temperature of adiabatic compression is:

$$t_c = t\left(\frac{p_c}{p}\right)^{\frac{y-1}{y}}$$

which in this case is

$$t_c = 290\left(\frac{10}{1}\right)^{.29} = 565^\circ \text{ absolute} = 292^\circ \text{ C.}$$

The temperature of explosion will be raised to practically this extent, or from 1,963° to 2,255° absolute. Using the same formula as before for the calculation of the pressure caused by this rise in temperature, we find $\frac{.908}{p1} = \frac{290}{2,255^\circ}$. From this p1 = 7.06 atmospheres, as the increase of pressure caused by the explosion.

We may now summarize the results of these comparisons as follows:

	B.T.U. per Cu. Ft. Gas.	Relative B.T.U. per Cu. Ft. Charge.	Explosion Pressure. Atmos.
1 vol. carb. water gas without compression.....	673	673	8.02
2.0 vols. blue water gas without compression.....	278	556	7.13
3.85 vols. blast furnace gas without compression.....	111	429	6.15
3.85 vols. blast furnace gas with compression to 10 atmos.....	111	429	7.06

The comparison has caused an increase of over an atmosphere in the pressure to be attributed to the explosion. This has been gained

apparently at the expense of the energy required to compress the gas, but in reality there has been no loss, because in the expansion the gas will theoretically return all the energy required to compress it. The gain has come purely from the greater temperature range and consequent greater pressure range through which the gas works. It starts the cycle under the pressure of compression plus the pressure of explosion which is nearly an atmosphere greater than the pressure of the same gas exploded without previous compression, and it ends the cycle at the same pressure in both cases. The energy required to compress the gas on the in-stroke is theoretically all returned on the out-stroke. The higher pressure caused by the increased combustion temperature is pure gain.

The figures indicate that when the charge is previously compressed to 10 atmospheres, 4 volumes of blast furnace gas are practically equal to 2 of blue water gas without compression, and that under like conditions 2 of blue gas are almost as good as 1 of rich carburetted gas. This gives some explanation of the rapid development of the blast furnace gas engine, which can work with higher compressions than engines burning hydrocarbon fuel. Does it also mean that the richer gases must always be at a disadvantage in this regard? Not necessarily.

Attention has of recent years been drawn again to a type of engine well known, but never successfully introduced into practice. Interest in this type has been aroused by the success of the Diesel petroleum motor. In this engine the piston on its return stroke compresses air only to a high pressure and a temperature hot enough to ignite any combustible. Just as the piston is at the dead point petroleum is injected into the cylinder, and ignited instantly on coming in contact with the hot air. Although this has been worked out on the large scale only for a petroleum motor, there seems no reason why the principle should not be successfully applied to gas. The gas may be compressed by a separate pump to a pressure sufficient to enable it to be forced rapidly into the cylinder at the proper moment. There can be no question here of premature explosion, and the only limiting condition would seem to be the mechanical one of making an engine to stand the strain.

The formula for calculating the theoretical efficiency of an engine of this type is not so simple as with the Otto engine. Efficiency will increase with the compression, but there will be involved the temperatures of compression, combustion and exhaust. It is almost useless to try to calculate the behavior of the engine if we also have to derive from rather uncertain theoretical data all three of these necessary temperatures. They are factors which it is extremely difficult to measure. The charge is compressed, exploded and exhausted in a fraction of a second, and it is almost impossible to obtain measuring instruments to register such rapid changes. Whenever we try to forecast the results of changes in a gas engine, or even interpret the results of experiments on our present engines, we are brought face to face with the painful inadequacy of our information on the subject of combustion in general and the operations in the gas engine cylinder in particular. The first step towards improvement is the determination and location of the present sources of loss.

We can determine the loss of heat to the jacket water, apparently inevitable and relatively constant. We can determine the loss due to the high temperature of the exhaust gases and to imperfect combustion, the latter, as Professor Mayer's researches have showed, being small with engines at full load running on lighting gas, considerably larger at half load, and rising to important proportions in engines using low grade gas; but we can only explain fully the results obtained when we are enabled to follow accurately every step of the process of conversion of chemical energy into power. The cylinder of the gas engine is still largely a sealed book. We do not know how rapidly explosion takes place nor how high temperatures are obtained. The very data on which the calculations just presented to you have been based are somewhat uncertain.

The metallurgist can produce almost any kind of steel demanded, from any materials furnished, and do it with certainty of success, and the electrical engineer will tell to a nicety just how a dynamo will behave before the design is off the drawing board, for the scientific investigations of many men have disclosed the important factors which will influence the result. The design of a gas engine is almost entirely a matter of practical experience. Like its governing, it is of the "hit-or-miss" order. Progress has been made in spite of the drawbacks, but nothing like the advance which would follow a scientific knowledge of the underlying phenomena.

The Institution of Mechanical Engineers, of Great Britain, deserves great credit for its support of research work on this subject for the past 5 years. Valuable results have been obtained, but the subject is too large and complex to be solved by any one set of investigators. It must be worked out bit by bit by many workers, with the expenditure of much time and money, but the results will be well worth the effort and will redound to the honor of all who have furthered the work.

Appendix.

The Calculation of Theoretical Combustion Temperature.—The tables given below have been calculated from the original data of Le Chatelier, to which references are given, and the method of calculation is indicated in every case. Specific heats by weight and by volume, both at constant volume and constant pressure, are given for carbon dioxide, water vapor, nitrogen, and oxygen for each 100° C. between 100° and 2,500°. The inaccuracies of the experimental data on which the tables are based render it useless to attempt to interpolate in the tables more closely than to 50°.

Calculation of Specific Heats According to Data of Le Chatelier.—Original References.—"If we represent by C_p and C_v the *molecular* specific heats, we have for all gases $C_p = C + 1{,}964$." (Mallard and Le Chatelier.) "Annales des Mines," 1883 (2); (512).

The *mean molecular* specific heat at *constant volume* equals—

$CO_2 = 6.50 + .00387$ t.
H_2O vapor $= 5.78 + .00286$ t.
Permanent gases $= 4.76 + .00122$ t.

"The specific heats of gases are independent of pressure, even at pressures of 6,000 to 7,000 atmospheres, and the specific heats of permanent gases are equal to one another even at high pressures and temperatures." (Le Chatelier; Seanc. de Soc. de Phys.; 1888, p. 308–327. Abstract in Wiedman's "Annalen der Physik," Beiblätter, 1890; Vol. 14, p. 364.)

For the calculation of temperatures of freely burning flames the specific heats at constant pressure must be used, which are obtained by adding 1.964 to the molecular specific heats at constant volume.

$CO_2 = 8.464 + .00387$ t.
H_2O vapor $= 7.744 + .00286$ t.
Permanent gases $= 6.724 + .00122$ t.

To obtain from these mean molecular specific heats the specific heats for 1 gram, we must divide by the molecular weights of the gases in question: For CO_2 by 44; for H_2O by 18; for N_2 by 28; O_2 by 32, etc. We thus get:

Mean Specific Heats for 1 Gram of Gas.	
At Constant Pressure.	At Constant Volume.
$CO_2 = .1923 + .000088$ t.	$.1477 + .000088$ t.
H_2O vapor $= .430 + .000159$ t.	$.3211 + .000159$ t.
$N_2 = .2401 + .0000435$ t.	$.1700 + .0000435$ t.
$O_2 = .2101 + 0000381$ t.	$.1487 + .0000381$ t.

As it is usually much more convenient to use the specific heats by volume, they may be calculated by multiplying these figures by the weight of a liter of the gas under standard conditions.

1 liter carbon dioxide = 1.965 grams; 1 liter water vapor = .804 grams; 1 liter nitrogen = 1.254 grams; 1 liter oxygen = 1.429 grams.

Mean Specific Heats for 1 Liter of Gas.	
At Constant Pressure.	At Constant Volume.
$CO_2 = .3779 + .0001729$ t.	$.2902 + .0001729$ t.
H_2O vapor $= .3457 + .0001277$ t.	$.2581 + .0001277$ t.
Nitrogen, Oxygen $= .3010 + .0000545$ t.	$.2132 + .0000545$ t.

Table I.

Table of Mean Specific Heats at Constant Volume Expressed in Calories per Liter.

Degrees C.	Carbon Dioxide.	Water Vapor.	Nitrogen and Oxygen.
100	.307	.271	.219
200	.325	.284	.224
300	.342	.296	.229
400	.359	.309	.235
500	.377	.322	.240
600	.394	.335	.246
700	.411	.348	.251
800	.429	.360	.257
900	.446	.373	.262
1,000	.463	.386	.268
1,100	.480	.399	.273
1,200	.498	.411	.279
1,300	.515	.424	.284
1,400	.532	.437	.289
1,500	.549	.450	.295
1,600	.567	.463	.300
1,700	.584	.475	.306

Degrees C.	Carbon Dioxide.	Water Vapor.	Nitrogen and Oxygen.
1,800	.601	.488	.311
1,900	.619	.501	.317
2,000	.636	.514	.322
2,100	.653	.526	.328
2,200	.671	.539	.333
2,300	.688	.552	.338
2,400	.705	.565	.344
2,500	.722	.578	.349
Difference each 100°	.0173	.0128	.0054

TABLE II.

Table of Mean Specific Heats at Constant Volume, Expressed in Calories per Gram.

Deg. C.	Carbon Dioxide.	Water Vapor.	Nitrogen.	Oxygen.
100	.156	.337	.174	.152
200	.165	.353	.179	.156
300	.174	.369	.183	.160
400	.183	.385	.187	.164
500	.192	.401	.192	.168
600	.200	.416	.196	.171
700	.209	.432	.200	.175
800	.218	.448	.205	.179
900	.227	.464	.209	.183
1,000	.236	.480	.213	.187
1,100	.244	.496	.218	.190
1,200	.253	.512	.222	.194
1,300	.262	.528	.226	.198
1,400	.271	.644	.231	.202
1,500	.280	.660	.235	.206
1,600	.288	.675	.239	.209
1,700	.297	.691	.244	.213
1,800	.306	.607	.248	.217
1,900	.315	.623	.253	.221
2,000	.324	.639	.257	.225
2,100	.332	.655	.261	.229
2,200	.341	.671	.266	.232
2,300	.350	.687	.270	.236
2,400	.359	.703	.274	.240
2,500	.368	.719	.279	.244
Difference each 100°	.0088	.0159	.0054	.0038

TABLE III.

Table of Mean Specific Heats at Constant Pressure, Expressed in Calories per Liter.

Deg. C.	Carbon Dioxide.	Water Vapor.	Nitrogen and Oxygen.
100	.395	.358	.306
200	.412	.371	.312
300	.430	.384	.317
400	.447	.397	.323
500	.464	.410	.328
600	.482	.422	.334
700	.499	.435	.339
800	.516	.448	.345
900	.534	.461	.350
1,000	.551	.474	.356
1,100	.568	.486	.361
1,200	.585	.499	.366
1,300	.603	.512	.372
1,400	.620	.525	.377
1,500	.637	.537	.383
1,600	.655	.550	.388
1,700	.672	.563	.394
1,800	.689	.575	.399
1,900	.706	.588	.404
2,000	.724	.601	.410
2,100	.741	.614	.415
2,200	.758	.627	.421
2,300	.776	.639	.426
2,400	.793	.652	.432
2,500	.810	.665	.437
Difference each 100°	.0173	.0128	.0054

TABLE IV.

Table of Mean Specific Heats at Constant Pressure, Expressed in Calories per Gram.

Deg. C.	Carbon Dioxide.	Water Vapor.	Nitrogen.	Oxygen.
100	.201	.446	.244	.214
200	.210	.462	.249	.218
300	.219	.478	.253	.222
400	.227	.494	.257	.225
500	.236	.510	.262	.229
600	.245	.526	.266	.233
700	.254	.541	.270	.237
800	.263	.557	.275	.241
900	.271	.573	.279	.244
1,000	.280	.589	.284	.248
1,100	.289	.605	.288	.252
1,200	.298	.621	.292	.256
1,300	.307	.637	.297	.260
1,400	.315	.652	.301	.264
1,500	.324	.668	.305	.267
1,600	.333	.684	.310	.271
1,700	.342	.700	.314	.275
1,800	.351	.716	.318	.279
1,900	.360	.732	.323	.282
2,000	.368	.748	.327	.286
2,100	.377	.764	.331	.290
2,200	.385	.780	.336	.294
2,300	.394	.796	.340	.298
2,400	.403	.812	.344	.301
2,500	.412	.828	.349	.305
Difference each 100°	.0088	.0159	.0043	.0038

TABLE V.

Relative Volumes of Certain Gases, and Their Products of Combustion in Theoretical Amount of Air.

Air contains 20.9 per cent. by volume of oxygen and 79.1 per cent. by volume of nitrogen, the ratio of nitrogen to oxygen being 3.784.

Name of Gas.	Volume of O Theoretically Necessary.	Volume of Carbon Dioxide.	Products of Combustion.—Water Vapor.	Products of Combustion.—Nitrogen.
Hydrogen	0.5	0	1	1.89
Carbon monoxide	0.5	1	0	1.89
Methane	2.0	1	2	7.56
Pentane	8.0	5	6	30.24
Hexane	9.5	6	7	35.91
Heptane	11.0	7	8	41.58
Ethylene	3.0	2	2	11.34
Propylene	4.5	3	3	17.01

As an instance of the method of calculating these temperatures we may take so-called "blue" water gas, made by blowing steam through white-hot coke, which will normally contain carbon dioxide, oxygen, carbon monoxide, hydrogen and nitrogen. Knowing the composition of the gas, we say calculate from Table V. the volumes of the products of combustion in the theoretical amount of air. We may also calculate from the analysis or experimentally determine the heating value of the gas. In the case of a simple gas like that under discussion the two methods of determining heating value will check closely, but in the case of complex gases carrying unsaturated hydrocarbons the experimental method is much to be preferred. In reporting the heating value of a gas, care should always be taken to distinguish between the "gross" and "net" value; the former being the result obtained in the calorimeter where the water formed in combustion is condensed in the instrument to liquid water, the latter being a lower value calculated from the first, where the water formed in combustion is assumed to escape as steam at the boiling point of water. It is evident that this "net" value represents more nearly actual conditions, and is always to be used.

Table VI. gives in detail the method of calculation for an actual sample of unpurified blue water gas, combustion taking place at constant pressure; that is, as if it were burned in the open air or in a furnace.

TABLE VI.

Calculation of Theoretical Temperature of Combustion of Blue Water Gas, with Theoretical Amount of Air, no Allowance Being Made for Dissociation of Products of Combustion.

Percentage Comp. of Gas.	Volume in Liters.	Vol. O_2 Required for Combustion.	Volume of Products of Combustion.—Water Vapor.	Volume of Products of Combustion.—Carbon Dioxide.	Volume of Products of Combustion.—Nitrogen Accompanying the Necessary Oxygen.
CO_2 4.4	.044	0	0	.044	0
O_2 0.3	.003	0	....	....	....
CO 41.0	.410	.205	0	.410	.775
H_2 52.3	.523	.261	.523	0	.988
N_2 2.0	.020	0	0	0	.020
100.0	1.000	.466	.523	.454	1.783
	Deduct.....	.003	Deduct for .003 Oxygen.		.011
		.463			1.772

Net heating value of gas, 278 B.T.U. per cubic foot, or 2,474 small calories per liter. Using specific heats by volume at constant pressure:

.523 × Sp. ht. H_2O	at 1,850° (= .581) =	.304
.454 × Sp. ht. CO_2	at 1,850° (= .698) =	.317
1.772 × Sp. ht. N_2	at 1,850° (= .402) =	.713
		1.334

$\frac{2,474}{1.334}$ = 1,854° = theoretical combustion temperature in deg. C. = 3,369° F.

We see that one volume of this gas will give .523 volumes of water vapor, and from Table III. that if we expect to raise one liter of water vapor from zero C. to 1,850° that there will be required as the *mean* value .581 calories for each degree. There will, therefore, be required in this case a mean of .304 calories to raise the water vapor derived from the combustion of one liter of this gas each degree from zero to 1,850. Determining in the same way the heat required for the proper volumes of carbon dioxide and nitrogen, we find that 1.334 calories will be the mean amount of heat required to raise the total products of combustion each degree from zero to 1,850°. We have available to heat these gases 2,474 calories, and the theoretical temperature would, therefore, be 1,854° C. The proper specific heat to be used (in this case for 1,850°) may only be found by trial.

Combustion in the theoretical amount of air is a condition never attained in practice. There is almost always an excess of air present, the amount of which may be calculated from the analysis of the gases after combustion. Knowing this we may calculate the highest temperature possible with our given conditions. As an illustration let us assume that when working with this water gas we find the following as the analysis of the gases after combustion: Carbon dioxide, 16.27 per cent.; oxygen, 4.15 per cent.; nitrogen, 79.57 per cent.

Each volume of this gas contains .415 volumes of oxygen, which will be accompanied by .415 × 3.784 = .157 volumes of nitrogen from the air. Deducting this amount, plus the .02 volume of nitrogen present in the original gas, from the total, .796 volume of nitrogen, we find .619 volume of nitrogen corresponding to the oxygen actually used for combustion. The .157 volume, therefore, represents the excess of air and the .619 volume the air theoretically necessary. The ratio between these shows that there was 25.4 per cent. excess of air present.

We may now calculate the maxium combustion temperature attainable under these conditions.

Percentage Comp. of Gas.		Volume in Liters.	Vol Oxygen Required for Combustion.	Volume of Products of Combustion—Water Vapor.	Carbon Dioxide.	Nitrogen.	Oxygen.
CO_2	4.4	.44	0	0	.044	0	0
O_2	.3	.003	0	0	0	0	0
CO	41.0	.410	.205	0	.410	.775	0
H_2	52.3	.523	.261	.523	0	.988	0
N_2	2.0	.020	0	0	0	.020	0
25.4 per cent. air in excess			0	0	0	.448	.118
			.466	.523	.454	2.231	.118
Deduct O_2 already present		.003	Deduct for .003 O_2.....			.011	
			.463			2.220	

Using volumetric specific heats at constant pressure. (Table III).

.523 × Sp. ht. H_2O	at 1,650° (= .556) =	.291
.454 × Sp. ht. CO_2	at " (= .663) =	.301
2.220 × Sp. ht. N_2	at " (= .391) =	.868
.118 × Sp. ht. O_2	at " (= .391) =	.046
		1.506

$\frac{2,474}{.1506}$ = 1,643° C. = 2,989° F.

In the same way it may be calculated that for a 50 per cent. excess of air the maxium temperature will be 1,470° C. = 2,678° F.

In the preceding cases it has been assumed that the combustion took place at constant pressure. In a gas engine where the explosion takes place approximately at constant *volume*, the theoretical temperature will be somewhat higher due to the lower specific heats. Referring to Table I., where the volumetric specific heats at constant volume are given, we may calculate:

.523 × Sp. ht. H_2O	at 2,100° (= .526) =	.275
.454 × " CO_2	" (= .653) =	.296
1.772 × " N_2	" (= 328) =	.582
		1.153

$\frac{2,474}{1.153}$ = 2,145° C.

The temperature which may theoretically be obtained in a gas engine is, therefore, with this gas nearly 300° C. higher than when burned in the open air. The following calculation of the temperature obtained from a carburetted water gas is an example of a more complicated case:

Theoretical Flame Temperature of Carburetted Water Gas.

Percentage Composition of Gas.	Volume in Liters.	Water Vapor.	Carbon Dioxide.	Nitrogen.
.12 C_2H_2.....	.0012	.0036	.0072	.0340
14.12 C_2H_4* C_3H_6* ..	.1412	.3530	.3530	2.0008
1.72 O_2	.0172	0	0	0
25.30 CO	.2530	0	.2530	.4781
22.40 CH_4.....	.2240	.4480	.2240	1.6390
28.30 H_2.....	.2830	.2830	.2240	1.6390
8.04 N_2.....	.0834	0	0	.0804
	1.0000	1.0876	.8372	4.8172
		Deduct for .0172	0.2	.0653
				4.7549

*The assumption is made that the unsatu ated hydrocarbons are made up of ethylene and propylene in equal volumes.

Using volumetric specific heats at constant pressure:

.8372 × sp. ht. CO_2	at 1,900° (= .706) =	.5910
1.0876 × sp. ht. N_2O	at 1,900° (= .588) =	.6395
4.7519 × sp. ht. N_2	at 1,900° (= .404) =	1.9197
		3.1502

Net heating valve = 673 B.T.U. per cubic foot (experimental value) = 5,990 calories per liter.

$\frac{5,990}{3.1502}$ = 1,901 = theoretical combustion temperature in degrees C.

Using specific heats at constant volume:

.8372 × sp. ht. CO_2	at 2,200° (= .671) =	.5617
1.0876 × sp. ht. H_2O	at 2,200° (= .539) =	.5862
4.7519 × sp. ht. N_2	at 2,200° (= .333) =	1.5824
		2.7303

$\frac{5,990}{2.73}$ = 2,190° C. = 3,974° F.

The following calculations are for a theoretically perfect blast furnace gas of 33 per cent. CO and 67 per cent. N_2, volume of products of combustion .33 vol. CO_2 and 1.297 N_2.

Using volumetric specific heats at constant volume:

.33 × Sp. ht. CO_2	at 1,700° (= .584) =	.1927
1.297 × Sp. ht. N_2	at 1,700° (= .306) =	.3969
		.5896

Net heating value 111 B.T.U. per cubic foot = 991 calories per liter.

$\frac{991}{5896}$ = 1,690° C.

When considering the relation which these temperatures thus calculated bear to those actually obtained, we may take into account; first, the influence of dissociation of the carbon dioxide and water vapor at high temperatures. The extent of this dissociation has been summed up by Nernst in his Theoretical Chemistry from Le Chatelier's work as follows:

"In the smelting furnace the temperature only extends to about 2,000° C., and the partial pressure of carbon dioxide only amounts to about 0.2 of an atmosphere; now, the carbon dioxide is decomposed only to about 5 per cent., whereby the capacity of the furnace for work is somewhat diminished, though not very much. With explosives, the temperature of combustion rarely rises above 2,500° C., and never reaches 3,000°. Inasmuch as the pressure of the carbon dioxide is here estimated in thousands of atmospheres, dissociation has no influence."

It is not easy to assign any definite volume to the influence of the other factors which prevent the attainment of the full theoretical temperature. The heat liberated never goes completely to raising the temperature of the combustion gases, but there are nearly always local points where the heat is almost entirely utilized in this way. In the case of a Bunsen burner flame the highest temperature found by the author experimentally was 1,780° C., while the temperature calculated was 1,850° C. Though the calculated temperatures are always somewhat high, they afford valuable information.

Some Conversion Factors.—1 calorie = 3.968 B. T. U.; 1 small calorie = .003968 B. T. U.; 1 calorie per liter = 112.36 B. T. U. per cubic foot; 1 small calorie per liter = .11236 B. T. U. per cubic foot; 1 small calorie per liter = 1 large calorie per cubic meter.

[Prepared for the JOURNAL.]

The Pitting Rust of Iron.

By DR. W. H. BIRCHMORE.

Two years since a very remarkable specimen of this strange injury occurring on the surface of a buried pipe was put on exhibition before a learned society of this country. Very soon after a large number of such specimens were put before those interested, most of which were privately circulated. Others were exhibited at society meetings. Some of these specimens were taken from gas mains, some from water and some from steam pipes; boilers, tanks and gasholders also furnished their quota. According to my diary I examined 14 of these specimens. They were from all sorts and conditions of iron material, and the iron was anything which it was permissible to call iron, from the "best Norway plate" to the cheapest pot metal—all sorts and kinds of iron were in the service shown to me; and the gentleman who stored the collection, and also one of his pupils, kindly went over the ground with me again and again until I fully understood the theory by which this professor proposes to account for so remarkable a condition of this material so important in the structures of our time. This gentleman in no way misconstrued the gravity of the questions or the importance of the trouble; indeed, while discussing it he used this very strange phrase: "So dependent are we upon iron for the construction of all our buildings and bridges that it is no exaggeration to call this the age of iron structures, and if those things are facts which we are fearing and not bogies, then our high buildings and bridges have no more real solidity, no more ability to stand the strain of time than the wooden halls of our ancestors." This gentleman's explanation of the phenomena will appear in due time, when the book on which he is working is given to the world. For the present his thoughts are his own; and his words, as the expression of those thoughts, belong not to the world but to his pupils only.

In this connection I need say no more than this. This explanation is plausible, if his premises can be proved true, or if they are accepted as axiomatic postulates; but to those who desire proof of the fundamental propositions the present position will be unsatisfactory. To my mind, as elaborate as is this theory in both conception and development, it seems to fall short of accounting for the whole, or even for the major part of the matter in hand.

On my return to New York I at once began a series of experiments to ascertain if possible some fundamental fact which could be the starting point of experimental study.

By experiments made at leisure, chiefly under complete quantitative control in the laboratory, and with all possible qualitative control, it seemed that something must turn up to indicate the line of least resistance and to show in what direction the inquiry should be prosecuted with the least certainty of being brought up in the same *cul-de-sac* which halts all other inquiry sooner or later. But while I think I may truly say that I have added three items of information, the string on which the items are to be threaded before they can be of any real use to anyone seems as far away as ever.

In respect to this form of iron rusting, which the chemists seem inclined to call "hydroxidation" and "per hydroxidation," two important facts must be observed. It occurs in some soils when dampened with any water; it occurs in any soil dampened with some waters. This would lead anyone to assume that the clue would be as easily found as the values of x and y in two simultaneous equations, since there are soils in which this form of rusting is said never to have been found no matter what the character of the water. But to the surprise of all interested the attempt to demonstrate this proposition was a total failure. No matter how painstaking and careful the work the result in every case was identically the same; nothing tangible. The result was peculiar. Utterly without reason, without the least indication of proof, certain persons affirmed that the result was caused by the action of bacilliform life and everybody was happy except the men who knew something about both the iron rust and the bacteria, and these were not happy; not at all.

A theory was formulated that since the yellow and red rusts were different chemically a variation in cause might also be inferred, which is no doubt a fact. Most remarkable is the influence of vegetable acids of the group commonly called "humic acids," and the strange "rotting action" which they have upon some irons, but by no means upon all. The very strange limitation of result indicating very interesting possibilities, both in respect to the geological history of ores and the future of many important structures.

In some water iron seems literally to vanish as metal, and no stain is left in the deposit from such water, even when the mud contains an unusually large quantity of iron. In some kaolin deposits in Ozark county, Mo., and in Arkansas, it is said that beds of milky whiteness contain portions which will turn blood red, when wet with boiled, distilled water, from the rapid change in the contained iron, and sometimes these spots are not larger than an egg. This has lead to an interesting theory on the origin of these beds. Other samples turn red on heating, even in an atmosphere of nitrogen, showing that the change is endo-molecular. These facts seem to indicate that the iron exists in a form not familiar to our laboratory experiments, and it is also suggestive of an interest as important in art as in science.

With respect to some of these specimens I have only information; in regard to others I know that the changes mentioned take place even when the specimens are heated in a vacuum sufficiently complete to cause the existence of X-rays; but the change, although produced by heat, is not produced by any of the extreme physical methods now in vogue These facts are mentioned because they are germane to phenomena to be discussed later on.

The special form of oxidation in respect to which most of my experiments were made and nearly, by intention, all my studies—for, incidentally, nearly every imaginable form of rust came under observation—was that form of which the characteristic is circumscribed pitting, as it was called by one who much aided me, "The pox-pit rust of iron." This name so exactly describes the chief characteristic that it should be the chosen designation in scientific language.

My interest in this special form of rust was much increased by the following circumstances: A building in which there was much iron was in process of "modernization," at the hands of an architect with whom I am on terms of familiar friendship, and who is an expert in "iron and steel for structural uses." In this building both iron and steel had been used in the form of rolled beams and plates, those last used to make built-up girders, and also much cast iron. The conductor pipes were, and still are, artistic structures of formed copper, and these were in structural contact with the iron forming an electrical circuit, and a current was proved to exist, and an amazing number of such currents were found in other parts of the building. At first we imimagined that we saw a relation between these currents and the destruction of the metal, but the more carefully we compared the details of our observations the less were we convinced that the relation was more than in appearance only. It is true that there was some rust in the places required by this theory, but not more than in places in which it was not required, or even should not have existed. After a carefully made study of the various forms of rust a classification of the forms of destruction was made with satisfactory results. It was the opinion of both of us that we recognized two distinct relations; in one, water in the liquid form had been in contact with the iron; in the other, it had not been in contact since the iron was in place.

When we compared notes we found that we both had recognized as fundamental that "the true pitting rust was to be found alike in form, and practically identical in distribution in all forms of iron and steel," and that "the use of 'coal tar' and 'metallic paint' made practically no difference either in the amount of rust or its distribution."

The Characteristic Focus.—Examination had impressed us both with the importance of this form of the focus of action. The sharp edges, as if a drill had been used, and the almost circular form, were shown in nearly every focus identified. Foci were found containing only a single "pock mark," and one was found which contained 283 "pock marks" within a circle 7 centimeters in diameter, say in a space as large as a palm of a large hand. Another irregular focus on a 20-inch I-beam, 14 feet long, contained 711 of these pits, some of them so small that it needed a strong magnifying glass to see them, while the largest was $\frac{5}{8}$ of an inch in diameter and fully $\frac{5}{64}$ of an inch in depth. In some instances (the older ones) the condition of the paint showed that the focus had been cleaned out and painted over, the pit being indicated by a depression in the paint. In some (a minority) this clearing out and painting over had put a stop to the destructive process; in others (the majority) the process had continued under the coating of tar or paint notwithstanding the clearing out process. [There is no proof that such clearing process was either systematic or complete in these cases.]

In many instances the proof was evident that the foci had been formed under the paint or bar, for these were absolutely smooth and intact, while under them were pits both large and deep, and many of these came to light only after they had been searched for with a pointed stick. This would break through the tar or paint into the softened contents of the pit which it was then possible to empty out.

In many instances the surface of the tar or paint was examined with a glass giving a power of 30 times linear. Such a power would make the $\frac{1}{16}$th of an inch seem to be equal to $1\frac{7}{8}$ inches, and not the smallest

indication of the mischief beneath would be detected, yet when the exploring surface was run over the surface holes would be found in all cases filled with the characteristic material.

It is worthy of remark that if moisture had reached this iron it had done so by passing by osmosis the covering of paint or tar. One inevitably asks, are these coats of paint really of any such air-tight quality as we are in the habit of assuming? to which one can only reply, "Who shall say?"

The Pits.—These observations at once classify these pits in two series; those which are exposed and those which are covered in by a more or less air-tight coating. The character of this coating and the exact character of the oxidized metal seem to be things indifferent.

As has been said these pits differ much in actual and relative dimensions. They also differ slightly in the character of the contents according to the environment.

This content may well be divided into: A, contents of pits which have apparently never been exposed to the action of air or water; B, those which have been exposed to air, and not to water, other than atmospheric moisture; C, those which have been exposed to water, but not to air other than that which is dissolved in water; D, those which have been freely exposed to both; and, E, those examples which are found in iron buried in the ground.

The instance in group A is intended specially to include the iron pipes covered with tar or paint, while the pipes in group E may have been tarred or may have been painted.

Covering pipes with asbestos packing and lime does not protect against this disease entirely, but it is easy to see that it does measurably. Grease, specially the heavy petroleum produced oils, does most remarkably act as a life preserver to iron. In four pieces of iron pipe which had been in sites for more than 12 years, and well covered with "heavy grease," the most painstaking examination could not find one pit, while in another subjected to exactly like influences and not oiled there were a great number of them.

Summarizing all the observations made it may be said that no condition was distinctly favorable to the preservation of the iron, except the presence of an oil analogous to the "gun-grease" made from heavy petroleums. It is well known that instruments well greased with this preparation "gun-grease" are safe from destruction, even in laboratories of whose atmosphere gaseous bromine and chlorine form a perceptible fraction.

Theories of Causation.—These have been abundant and have run the whole gamut of possibilities, from electrolysis to bacteria. In respect to theories of chemical action it may be said that they practically center around the action of ammonia, and the most numerous studies have been made upon buried pipes. These soils have this distinctly marked characteristic (?) that they, like all other fertile soils, contain ammonia. Since it is known that the ammonia in the soil is produced by the action of bacteria certain of the writers on this question jumping one step have at once said the cause is "bacteria," which conclusion does not simplify matters to the least degree.

The soils have certain distinct characteristics which it has been assumed by certain persons play an important part in the destructive movement. They always contain a certain relatively large amount of ammonia in some combination which is believed by many to be extending itself in the direction of nitric acid, which it must eventually form in due time by oxidation.

Objection to this theory frequently offered is that these facts taken alone will not justify all the conclusions promulgated in this direction, and when this contention is enforced the advocates shift their ground, and, introducing some hypothetical entity of the disease germ type, claim as essentially vital an action which they had but just declared to be wholly chemical in type. It is not my intention to say that a chemical action may not sometimes have a vital action as a causation element, but so far as this "pox pit" rusting it is essential that the hypothesis should be unqualifiedly proved to be true, and this I protest has not yet been done.

My Own Experiments.—My personal observations on this matter are confined to three series: A, observations on unpainted iron; B, observations on painted iron; and, C, observations on "tin-plated iron." Under each series were three sets of samples: 1, buried in the soil; 2, submerged in water and again in air; 3, those submerged in air only.

It might be well, but it certainly would be tedious, to give the diary of all these observations. It is enough to say that I have found some new facts, or, more accurately, have made some observations which indicate that by no means the whole of the questions involved have been investigated, some of which seem to show that much which we fancied was specific is really generic, and much the reverse.

For example: I have the best possible proof that the rusting of tinplate always begins in minute circular spots. I have also found that rusting will take place under the paint on a painted surface, even when the iron was boiled in a solution of pot. cyanide, for the sake of reducing the rust to metallic iron before painting, should there by any chance be any rust present to reduce.

This series of observations show that "mineral paints" and "metallic paints," neither of them, will protect from rusting iron which is alternately wetted and dried. There is no room for question as to the fact, but I am not quite ready with an explanation. I have two pieces of iron which were submerged from 4 P.M. to 9 A.M. for three months, the rest of the time being in the air and supposed to be dry. Both of these pieces have the surfaces entire, so far as the paint is concerned, and yet the iron within is destroyed. In the tin plated samples the case is the same.

In some cases photographs were made showing the changes from day to day, and careful measures show that the arear extent was increased almost exactly as the square of the time, indicating that the rate of movement depended wholly upon length of exposure to the action, whatever it may be. Nor are we fully in possession of all the facts bearing upon this question.

The only absolutely efficient protection from rust which I have found is paraffine. Iron coated while warm with warm paraffine accepts a thin coating which, in so far as three months' observation goes, shows a complete protection from this rust or another.

The Final Question.—The final question, is this. The normal form of rusting in iron I think must be answered in the affirmative. Why iron plates of the modern manufacture should show this peculiar rust method no one can say; but should rusting be possible it seems by so mysterious a selection process to take this form. In the tin plated iron it was a very easy thing to show (microcopic examination was the method) that the rusting foci were even in some cases less than $\frac{1}{10000}$th of an inch in the beginning. In other cases the tin was evidently oxidized before the iron over an area three to four times the size of the original focus of the iron rust, but more frequent, was a reversal of this process, the iron rusting away and depositing itself on the outside of the tin plate. Samples of so-called Russia iron were somewhat less rapidly assailed, but in the end as effectually.

To test the effect, rather than with any expectation of success, samples of iron were plated with copper and then with nickel; but this only hindered, it did not prevent the rusting.

However, some few questions were made to stand out distinctly, and these were carefully taken up one by one and will be made the subject of a detailed study.

For the present I can only say that anyone who has a holder or gas pipes troubled with this rust will confer a favor by writing to me, and if he has a sample of gas pipe which shows this rust, a sample to add to my collection with a statement of all the known facts will be most welcome.

Perhaps the most remarkable fact which has been brought out in this whole inquiry is this. In every case in which a rust pit was developed on one surface a corresponding pit was almost or quite simultaneously developed in the other; this when both surfaces were protected by paint.

Should it be permitted me to continue this study my next paper will be illustrated by photographs of the plates showing the relations of the rust foci. At present the writer can only say that his experiments have made manifest the necessity of inquiry in three special directions. 1. cases in which the iron was subjected to the combined action of water containing in solution ammonia and carbon monoxide, such iron afterward being subjected to atmospheric action; 2, cases in which the iron was buried in a soil containing ammonia in oxydizable relation; 3, cases in which ammonia and sulphur, usually as hydrogen sulphide, could both be demonstrated. In one special case the writer found 3⅝th nearly as much sulphates in the water of the well of the gasholder as was present in the water supply. How far this was causative, and how far an accident, he does not know.

JUDGE DILLON, in deciding the case of the City of Columbus, O., against the Federal Gas Company, of that city, to declare its franchise void, held that there had not been any illegal acts on the part of the Company of sufficient gravity to forfeit its franchise, but said that, as the petition claimed a contemplated sale of the property to unknown parties, he would, if desired, withhold the entry and enjoin the sale until the city could set forth any facts it might have. Attorney Williams, representing the Company, denies knowledge of any such sale, and Attorney Sater stated that he would have to consult the city law department before taking such action.

New Uses of Concrete in Building Construction.[1]

One of the important factors in connection with the recent remarkable development of the American cement industry is the increasing attention which is being directed to the use of concrete in building construction, chiefly in the form of reinforced concrete. The ease with which concrete can be molded into monolithic forms, its great strength, the absolute protection which it gives to iron and steel imbedded in it, and its fireproof qualities, which have been established beyond doubt, combine to make it a material of the highest value. The idea of reinforced concrete, *i. e.*, concrete strengthened by light steel bars or wire netting, or expanded metal imbedded in it, was first developed in France by J. Monier, and early found application in metallurgical engineering in the construction of dust and fume settling flues. These have become standard practice, and are to be seen at nearly all of the most recently constructed lead and copper smelteries in the United States, notably at the new plant of the American Smelting and Refining Company, at Murray, Utah. In general building construction the Monier system has been more generally adopted in France and Germany, but during the last few years its use has become considerable in the United States.

There are a number of patented modifications of the Monier system. Among these may be named the Ransome, in which twisted steel bars are used; the Hennebique, using round steel bars and a certain style of stirrups to resist shearing; the De Valliere, differing from the Hennebique principally in the style of the stirrups employed; the Thatcher, using strengthening bars with projections in connection with the concrete; the Columbian, using special forms of rolled steel; the Roebling, in which a netting and rods are used principally as centers for concrete arches; the expanded metal system, used only for slabs and not for beams; and numerous other less well known systems. A recently introduced fireproof roofing material is "ferroinclave," made of sand and cement in the form of slabs 1.5 inches thick, in the center of which is incorporated a sheet of steel, corrugated deeply in a peculiar manner.

The most ambitious example of reinforced concrete construction is the now famous Ingalls building at Cincinnati, which has attracted deep engineering interest. This is a 16-story building, which is practically a monolith of reinforced concrete (Ransome system). It is 50 by 100 feet in area and 210 feet in height. The concrete used in its construction is composed of 1 part Portland cement, 2 parts sand, and 4 parts of hard limestone of 1-inch size.

Another system of construction that is extending to a marked degree is the use of concrete blocks. An example of this kind of construction is the method of the American Hydraulic Stone Company, of Denver, Col., described in the *Engineering News* of September 17, 1903. Walls built of concrete blocks are usually hollow, and may be of "one-piece" or "two-piece" construction. In the former case each block is hollow, and its width is equal to the thickness of the wall. In the latter case the blocks are approximately of **T**-shape in plan, set on edge, so that two blocks form the inner and outer faces of the wall, their ribs, 12 inches apart, serving as cross bonds. The American Hydraulic Stone Company is exploiting the latter system. The blocks are usually 9 by 24 inches on the face, the ribs varying according to the thickness of wall required. The regular blocks weigh 38 pounds each, and a wall built of them contains 52 per cent. open space. The blocks are molded from a mixture of 1 part cement to 6 or 8 parts of ¾-inch crushed stone under hydraulic pressure of 30 to 35 tons. For an ordinary 3-story building, walls of this construction 9 inches thick are sufficient. For a higher building, or for heavy construction, the walls of the lower stories should be 12 or 14 inches thich, or a 10-inch wall may be used, some of the hollow spaces being filled with concrete to form piers. For interior partitions, 4-inch to 8-inch walls are sufficient.

The blocks are made by three styles of hydraulic press—(1) a portable hand press which will turn out (with 5 men) 400 blocks per day; (2) a power press, operated by electric motor or gasoline engine (to be used in connection with a power concrete mixer), which will turn out (with 6 men) 1,000 blocks per day; (3) a heavy duty machine, operated by a 10-horse power engine (serving both for the press and the concrete mixer), which gives 35 tons pressure to each block and turns out (with 8 men) 1,500 blocks per days. Two masons and a helper can lay 400 blocks in a day.

Mr. F. E. Kidder reports that with hand mixing and a handpress, operated by 5 men, the cost of making blocks 8¾-inch by 23¾-inch for a square yard of 10-inch wall (12 blocks required), the concrete being 1 part cement to 6 parts sand and gravel, was 0.78 sack of cement (4 sacks to the barrel), 4 cubic feet of gravel, and the labor of one man for 1.25 hours. Reckoning labor at $2 per 10 hours, gravel at 75c. per load of 1.25 yards, and cement at $2.50 per barrel, the cost per square yard was 84c. Allowing 48c. per square yard for laying and mortar, and 10c. per square yard for carting, the total cost per square yard of wall erected was $1.43 = 15 7-9c. per square foot. As compared with walls of common brick, faced with pressed brick, this is a great saving. It is indeed considerably lower than what the most ordinary brick masonry can be laid for, since a 10-inch wall of this concrete construction will satisfactorily take the place of a 13-inch or 17-inch brick wall. It should be noted also that Mr. Kidder's test was made with hand machines, and naturally the cost of the blocks would be reduced by mechanical mixing and power press. The figures refer, moreover, to so-called "faced" blocks, in the manufacture of which 0.25 inch of the concrete is scraped off the face, which is then surfaced smoothly with 1:2 cement. When taken from the press the blocks are stacked up for 10 days, and are kept moist by spray from overhead sprinklers.

This appears to be a form of building construction which is well worthy of attention, not only because of its economy, but also because of its advantages in other respects. The hollow walls, divided by partitions, make the building cool in summer and warm in winter, while the spaces can be utilized for heating and ventilating flues, electric wires, plumbing pipes, etc.

1. *Engineering and Mining Journal.*

Notes on Lighting in Europe.

Mr. Arthur Williams, of the New York Edison Company, prepared for the Association of Edison Illuminating Companies, at the Thousand Islands convention, a very interesting paper on what he had seen of European lighting practice during a recent trip abroad. One thing he observed was the absence of electrical effects upon special occasions, as for example, the visit of President Loubet to London. As to arc lighting in that city, he remarked that the prices paid by the municipality vary from $110 to $150 annually for an arc lamp of about the same size as our lamp *rated* at 2,000 candles. The practice is to place the lamps much nearer together, in many instances averaging not more than 100 feet apart, and the result is a degree of lighting which would offer a useful, impressive example to those in charge of that kind of service in most of our American municipalities. The city furnishes the posts and shades; the companies provide all else, giving the lamps the usual attention.

Inclosed arc lamps have made very little headway; the few to be seen are of a design less satisfactory than that with which we are familiar here, and for the most part they have not given satisfaction to the users. The reason the English engineers adhere so devotedly to the open lamps is that in London and other English and European cities, the price of labor and carbons is low, while the cost of current is high —the reverse being true in our American cities.

The Siemens-Halske Company has just placed upon the market a very small inclosed arc light, called the "Lilliput;" in deference to its lack of size. This lamp is so small that it can be used directly over a writing desk, near one's work, or, in fact, in any position sufficient for the usual incandescent lamp, and in which a large volume of light is required. It is even shown in the conventional desk standard, in which heretofore the incandescent lamp has been supposed to find an exclusive field. The lamp may be placed in any position without affecting its accuracy or steadiness of feed.

"Bremer" lamps are seen frequently on the streets. The outside of one hotel or restaurant on Piccadilly Circus is strikingly illuminated by them. The color of the light, however, is not pleasing, and he questioned whether, unless changed, the lamp will soon become very popular. It is said that about 150 are now used, with very great satisfaction, for lighting the streets of one district—that surrounding the East India docks. The lamp has recently been improved, and all now in use are to be replaced with the new type as soon as practicable. The object of the improvement is to do away with "fluttering," which heretofore has been a chronic defect. As all doubtless know, these lamps burn two in series, about 50 volts each, on a 110-120 volt circuit.

These lamps, as incandescent lamps and all other features of the installation, must be purchased by the consumer, but to insure good service, the manufacturers—The Westinghouse Company—arrange for their care at a cost of 10 shillings, or $2.50 weekly—for two—the price including, inspections, carbons and repairs, but not the current supply. The responsibility of the company supplying electric current ends at the meter, and so everybody seems to understand. This Mr. Williams considers not conducive to best service. It compels the

customers to purchase incandescent lamps, without expert knowledge and at a price in excess of the cost of lamps to the supplyiug company, tending thus to prolong their use until breakage, however blackened or low the candle power has fallen. The incandescent lighting standards are low, and as the service rendered by the companies is said to be very satisfactory—it is evident that they are carefully managed—the cause must be found in the lamps.

In the business sections one sees little gas lighting, and it is said that there is but one oil lamp installation in the city—and that that is going out. The "Lucas" lamp comparing with the "Northern" here, is used, but apparently not to any great extent. Electric light seems to have little, if any, serious competition.

Nernst lamps large and small, are to be seen frequently on the principal thoroughfares, and the light is of very satisfactory quality. A number of stores use them exclusively. Plain, ground or opalescent glass globes are used, with vertical spiral glowers—distinct from the horizontal straight glowers with which we are familiar in American practice. Large lamps, consuming about 250 watts, cost the retail consumer $5; small lamps, $1.25; large glowers cost 50 cents, the small, 37½ cents. They can be used with either alternating or direct current—those he saw used the direct current.

A Nernst projector lamp of 1,000-candle power has been made. The lamp consists of 3 glowers, in parallel, placed on a white enamel disk of about 2½ inches diameter. About 300 watts are consumed and hand control is substituted for the usual automatic control.

A representative of the manufacturers stated that 400,000 of these lamps, 60 per cent. small, the remainder large in size, were sold in England during the last year. It should be remembered that the incandescent lighting standards are generally *low*, and, therefore, a greater relative growth than would be possible here, should be expected.

There are 36 companies or vestries in London operating electric lighting plants. The aggregate of the installations, on the 16-candle basis, is 2,476,491 equivalents. This is largely incandescent lighting; the motor installations aggregate hardly more than 5,000-horse power, and the arc lamps something less than that number.

It has been stated that 13 of the companies or vestries use Wright meters, not exclusively, but in conjunction with their rates. The companies using these meters control about 45 per cent. of the total installations, but Mr. Williams got no data as to the number of meters used, or on the percentage of current sold through them. The manager of one of the largest companies stated that though he was reported as using this system of discount, he actually had only a few of the meters. The Shattner demand meter is also in use; one advantage being that it can be made fast or slow, as desired, by simply changing the medium through which the balls fall.

So much has been devised and said concerning electric lighting rates that it would seem as though nothing new were possible. Yet he had not previously heard of the rate recently adopted by the St. James and Pall Mall Company for long hour, usually hidden lighting; by hidden is meant the lighting of hotel, apartment house and club cellars, kitchen and servants' quarters, shops below the sidewalk level, basements and the public conveniences, which the city of London has liberally provided at the large intersections. The retail rates of this company are 12 cents a kilowatt hour for the first 4,000 kilowatt hours of annual use and 8 cents for all over, with a discount of 8 per cent. on all bills paid quickly—say within 30 days. To meet the competition of gas in the places mentioned, the company has adopted a new schedule, under which all "below street level" lighting is supplied at exactly half the usual rates. That is to say, the first 4,000-kilowatt hours are charged for at 6 cents instead of 12 cents, and the remainder at 4 cents instead of 8 cents—and the additional discount of 8 per cent. is also allowed.

If the consumer's premises are half above and half below the street level, he is given the benefit of a liberal interpretation of the schedule, and charged altogether at the low rates. Separate meters are provided where necessary to separate other parts of the premises supplied at higher rates. This schedule has been very successful in competing with gas service.

English or perhaps London views regarding credit are interesting. Payment within 30 days is considered cash; 9 months are not unusual.

It may be of interest to know that one company charges 12 cents a kilowatt hour for service at 100 volts and 10 cents where taken at 200 volts. This method has probably been adopted to encourage a general change of installations to the higher voltage. Another company, or rather one of the borough councils, charges 16 cents a kilowatt hour for the first hour of the maximum demand, and 2 cents for all over—a schedule representing the extreme views of Mr. Arthur Wright, in connection with the Wright demand system. Another company has recently entered upon a large contract for lighting and power service, under which the consumer pays $75 annually for each kilowatt of maximum demand and 2 cents for each kilowatt hour consumed. The demand rates of this company are also interesting. For the first quarter, ending with March, the charge is: For the first 6 kilowatt hours consumed per 8-candle power lamp, or equivalent, 16 cents a kilowatt hour, and for all excess, 4 cents; for the quarters ending with June and September only the first 3 kilowatt hours of average use are charged for at the higher rate, the remainder being charged for at the lower rate; the quarter ending with December, filling out the year, is again increased to an average of 6 units at the higher rate, as with the first quarter. Power is sold at 5 cents a kilowatt hour for the first 250 kilowatt hours of annual consumption per kilowatt of installation and 2 cents for all consumed in excess.

It should not be forgotten, when considering English terms, that the consumer buys everything beyond the meter, and therefore, on any prices given, fully 1½ cents a kilowatt hour should be added to get an American comparison.

The Shoreditch Destructor Works, of which so much has been said, are still in operation. This plant, it will be remembered, was erected for the purpose of burning the garbage of the district, utilizing the heat for making steam, the live steam for operating an electric light plant, and the exhaust for heating the water of the municipal bath of the district, and in winter for heating the district library. These several departments are located contiguously in the same block, but front on different thoroughfares. A second lighting station, some distance from the first, has now been erected, the capacity of which is about 1,600 kilowatts, but it is operated entirely with coal fuel. The works remain substantially as they were when first finished, though because of the larger demand for electric current and the somewhat lessened supply of debris, more coal is now being consumed than formerly. The consumable debris of the district amounts to 25,000 tons annually and gives sufficient heat to produce 1,000,000 kilowatt hours. It is estimated that garbage produces on an average one-tenth the heat of ordinary coal. Curiously, the garbage supply is decreasing. This is because dwelling housee are being gradually replaced, as the city pushes out, by factories and stores, which in proportion contribute less. The new inhabitants, however, demand more light and power service, so that the works can well afford to burn as much additional coal as may be required.

The figures showing the result of last year's operation seem to make it difficult to prove that the electrical are paying features of the plant. There was a balance of $20,000, after all charges were met, credited to the sinking fund, but this amounts to only 1.5 per cent. of the cost, a rate of depreciation demanding an active life in excess of 50 years to equal the original cost of the plant.

The use of arc lamps for the street lighting in Paris, as in London, has increased largely in the last two years, the greatest change being in the center of the city. Open burning lamps are used, again because of the low cost of carbons and labor and the high cost of current. The lamps are spaced apart an average not exceeding 100 feet; in some places the distances are much less. There seems to be no desire on the part of the city officials to utilize the private window lighting for the illumation of the thoroughfares, and this is well, for there is little, if any, display lighting of that order that is worth mentioning.

The companies supplying electric current are limited in their franchise to a maximum price equalling 30 cents a kilowatt hour, but there is no limitation upon the extent to which this price may be reduced. The average price obtained is about 22 cents a kilowatt hour.

Companies making electric current inside the city's walls pay a tax of 5 per cent. on their gross income, while those who generate outside the walls, thus avoiding the duty paid upon coal brought within the fortifications, pay 1 per cent. additional, or 6 per cent.

The cost of municipal arc lighting, where supplied by private companies, is at the rate of $240 annually, but the annual expenditure is in many cases lessened through the disconnection of the lamps at midnight or shortly thereafter. As the companies are taxed upon their gross income, this figure is reduced 5 per cent. or 6 per cent., as the case may be, so that the net cost is not far from $225 a lamp annually.

At the end of 1901 the five private companies and the municipal plant of Paris had 68,267 kilowatts of installation, equalling 1,365,340 16-candle equivalents. The capacity of all the stations was 38,000 kilowatts, or 56 per cent. of the installations. Twenty-seven million three hundred and twenty-two thousand kilowatt hours were sold, the consumption averaging about 400 hours per unit of installation.

A very interesting map has been prepared by the engineer in charge

of the municipal works, showing in each of 83 small sections, into which he divided the city, the installation capacity in kilowatts, the kilowatt hours consumed annually, and the average use of each unit of installation. For example, one, a rich residential section, is shown where 3,387 kilowatts installation have an average use of only 161 hours annually; a second, next it, having 1,895 kilowatts, averages only 147 hours. The business and small shop sections appear better; in one 2,301 kilowatts were used, an average of 585 hours; in another 1,717 kilowatts, an average of 887 hours, and in still another, 135 kilowatts averaged 734 hours. A section in which the installations are largely for city lighting, having 102 units, averages 3,061 hours; another, also devoted to city lighting, having 26 units of installation, averages 2,284 hours. As stated previously, the average of all is 400 hours.

Three reasons are given explaining the very limited use of electric light in Paris. 1. The high price, having little effect upon the rich, but largely restricting or preventing its use by others. 2. That electric light will always be very costly, even after reductions are made; that it cannot be used by "the little well-to-do." 3. The limited durance of the concessions, causing the supplying companies to withhold outlays for new equipments and extensions, requiring that they maintain a price abnormally high, to insure a fair return upon the investments they have made.

Central Station Heating.

[A paper read by MR. D. F. M'GEE, before the Iowa State Electric Light Association.]

If we are to take up the subject of central station heating from a mechanical and financial standpoint it will be necessary to weigh very carefully the many points which cause the plant to be a financial success or a failure.

Spreading out promiscuously all over town must be avoided, and only just sufficient mains should be installed to use up all the available exhaust steam. The proposition should be to utilize only the exhaust steam to the best advantage. The claim of certain promoters of heating systems that there is money in live steam heating, and that the electric light and power furnished need only be considered as by-products, is untrue, and has resulted in the installation of heating plants which cannot be run on a paying basis.

My experience with the various steam, hot air and hot water systems has convinced me that nothing meets the universal requirements for a central plant as well as hot water heat. In fact it is the only heating system in which regulation of temperature in the various buildings is absolutely under the control of the attendant at the central plant without a complicated system of thermostats, that increase the first cost of installation and are always getting out of order, and are consequently a continuous source of expense.

In our plant we have posted near the thermometer in the main supply pipe a carefully tabulated schedule by which the engineer can tell at a glance how hot the water must be to warm the buildings to 70° at any given outside temperature. As a result our customers seldom touch a radiator valve during the entire season. The fact that the temperature of the heating surface in the entire system can be controlled is of particular advantage in moderate weather, for by controlling the temperature with a hot water system a given amount of heat can be spread out thinner and do much more work than the same amount of heat will do with a steam system. The customers need not touch an air valve, consequently that disagreeable odor of cylinder oil, so much in evidence where exhaust steam is used direct for heating, is entirely eliminated, as well as all cracking and snapping of pipes, so familiar to us all where steam is used for heating buildings.

To make a plant successful every corner must be guarded, and frequently small economies determine whether the plant is profitable. To illustrate: In operating an exhaust steam heating plant there occurs loss of power and useful work due to back pressure. It often amounts to 25 per cent. of the power developed, and in some cases to as much as 50 per cent. There is also an important loss due to throwing away the water of condensation, a common practice in exhaust steam heating. Aside from the value of the heat so wasted, the loss of so much pure distilled water, so good for use in the boilers, is a considerable item.

In operating a hot water system some power must be used to circulate the water.

I know of no better way of taking up this subject intelligently than to give you a brief description of our plant, with a statement of results which we have obtained.

Our pipe system consists of a closed loop or circuit of 5-inch pipe, about ¾ mile long, with 3-inch shunts, each about 1,000 feet, extending off the main line. In this circuit and part of it are a centrifugal or fan type of pump, an exhaust steam heater and a live steam or auxiliary heater. The exhaust steam from our engines first passes through an open feed water heater and grease extractor, which heats feed water for our boilers and also removes the cylinder oil from the exhaust steam. It then passes through the exhaust heater for the heating system, where it gives up its heat to the circulating water, the surplus, if any, escaping to the atmosphere.

As this exhaust heater is elevated above the water line in the open feed water heater, the condensation from the exhaust steam flows to the feed water heater by gravity, to be pumped to boilers as feed water. This insures us distilled water for our boilers at a temperature of at least 205°, and enables us to use our water over and over again, which makes a very material reduction in our water bill as compared with those we pay in the summer months. There is an opening direct to the atmosphere from the exhaust heater at all times, so it is impossible to put any back pressure on our engines, and indicator cards taken from engines show that we can condense every particle of our exhaust steam without using an ounce of back pressure.

The live steam heater is elevated some distance above the boilers and is similar to the exhaust heaters, only much smaller. Here also steam passes through tubes surrounded by the circulating water of the system. When live steam is required for heating it is taken from the main steam pipe direct to this heater. The condensation from the live steam returns to the boilers by gravity at a temperature corresponding to the pressure. This means returning the water to the boiler at a temperature of over 300°, instead of allowing it to flow to the sewer, which is done in all steam plants and other hot water systems, where it must be replaced by water at an average temperature of 40°.

Any person who ever tried to run a large heating plant where extra boilers are used to heat the water knows that it is an absolute impossibility to regulate the temperature of the water, as the grate surface necessary to heat sufficient water to warm the buildings at zero weather would be too large when the weather is 30° or 40° above zero, consequently the water is either too hot or too cold, and by attempting to regulate the fire you must necessarily waste a great deal of coal. We are able to control the temperature of the circulating water to a degree, this being done by merely opening and closing a valve. This means a very large saving when it is necessary for us to use live steam, which is on Sundays, holidays and when the weather is about 10° above zero during the daytime, as we find that at about this temperature our exhaust steam is not sufficient to heat the water warm enough.

Our circulating pump is of the centrifugal type, and requires only 12-horse power to maintain a difference of 20 pounds between the supply and return, that being our circulating pressure.

Our system is a closed one and we do not have the static head of water to pump against. The pump gets the benefit of the pressure due to the height of the highest radiator on the suction side of the pipe, which any system using a so-called storage tank is compelled to lose, as the storage tank leaves an open place in the return circuit. Such a system calls for a steam driven duplex pump, which type of pump requires at least 150 pounds of steam per horse power hour, while our pumps are driven from a Corliss engine with an economy of about 28 pounds of steam per horse power hour. Now even if our system did require the same amount of power to circulate the water that other systems do, the difference in the type of pump employed would show that we only use one-sixth as much steam to do our pumping; but further than this, we only pump against one-third as much pressure. Consequently we use in doing our pumping about one-eighteenth as much steam as the other systems.

Our house connections are merely shunts taken off the mains. The size of each house shunt depends upon the number of feet radiation required in the building to be warmed.

Our plant was started up in October, 1899, and the first season we had about 14,000 square feet of radiation in service. This gave us a loss of 8° from the time the water left the plant until it returned, and when the thermometer was 10° below zero. This year we have increased our load to 29,000 square feet, and the difference during our coldest weather is 15°. I have learned from experience that it is a great advantage to make the house connections a little large, as we found last winter that we could shut down our pump for five or six hours at a time without our customers being aware of it, as the water, having acquired its momentum while the pump was running, continued to circulate after the pump was shut down, passing through the exhaust heater to be reheated and then acquiring motion from the change in

temperature. Just so long as the water remained warm in the mains it continued to circulate through the buildings that were equipped with 1¼-inch and larger sized street connections. This year, for buildings requiring 1,200 square feet of radiating surface and less, we made the street connections 1¼ inch. For buildings requiring a larger amount of radiation 2-inch connections.

We have all learned that to make an electric plant pay we must avoid the slipshod methods of construction which were considered good enough a few years ago. It was then thought that any kind of an electric plant was a gold mine, and we will do well to profit by the sad experience of a great number of lighting plants which were thrown together with this expectation.

To place a heating plant on a paying basis it is necessary to watch and take advantage of every point. Do not think that you can dig a hole in the ground, lay in it several miles of pipe, throw a few boards around it, run a block here and a block there for every building, and expect to pay 100 per cent. on the investment, simply because some smooth fellow tells you that a heating plant is a gold mine.

In the first place, all underground work must be done in the best possible manner, bearing in mind that the mains cannot be covered too thoroughly with a non-conducting material. All pipes should be thoroughly tested and leaks repaired while they are yet uncovered, for every drop of water—in fact, every heat unit—represents money invested, and should be guarded accordingly. It pays to cover all cellar piping, such as mains and branches, with a non-conducting material at your own expense. I find that $\frac{1}{32}$-inch asbestos paper, which comes in rolls of about 100 pounds, answers this purpose very well. We saw the roll up into blocks about 6 inches in length. This gives us long strips of papers 6 inches wide, which should be wound spirally around the pipe, first in one direction and next the reverse, until there are several thicknesses around the pipe. This is much cheaper and very nearly as effectual as sectional covering.

As I receive very many inquiries about our system of charging for service, a few words on that point may be of interest. We charge a uniform price of 15 cents per square foot for all radiating surface in actual use, making no distinction between large and small customers as to price. But we make this arrangement, which seems to meet the requirements: When our large customers, such as office buildings, have rooms which are not rented we disconnect and draw the water out of radiators in these rooms. We take this precaution to avoid any danger of the water freezing in the radiators. We have in actual service this winter 28,000 square feet of radiation, which brings in an income of $4,320. Coal costs us $1.69 per ton laid down in fire room. The amount of coal chargeable to heating service for each month, including Sundays, when we do not run our engines, is as follows:

October	8 tons.
November	16 "
December	40 "
January	60 "

Judging from this we expect to burn about 300 tons of coal for heating purposes during the year, which will cost us about $500. This will leave a net income of about $3,800. While this has been an exceptionally mild season, still a lower temperature would not increase our coal consumption very much, as Sundays are practically the only days that we find it necessary to use very much live steam. So far we have a very satisfactory plant, yielding a good income. (Cost of plant under $10,000).

Now the question of extending our system comes up. Our customers who have the heat in their business houses want it in their homes, and we could double the amount of radiation in service by extending our mains, and our station apparatus was planned for this. Yet we have decided not to do so, for when we take into consideration the interest on the additional investment for street mains and the fact that we would then be compelled to burn coal, make steam to heat our water, and probably require extra boilers, we fail to see where there is any money in the extra investment and expense. Now we find that to make the investment very profitable it is important to have a day load for the engines. This perhaps can be done to the best advantage by furnishing electric current to your customers for light and power at a rate which will make it an object for them to use it and still permit you to sell it at a profit. This is a point that is apt to be overlooked by many central station men.

The promoters of heating systems tell us that we can sell our electric current very low, because we will be deriving an income from the sale of our exhaust steam for heating purposes; and then, in the next breath, they tell us that we can make a low rate for heating because we are utilizing our exhaust steam as a by-product.

A few moments' reflection will convince any man that it is impossible to cut on both ends of this proposition and still come out ahead; and it is not necessary to do so if it is undertaken in the proper manner.

Our local conditions are similar to nine-tenths of the lighting plants in this State, and I find that it is not very difficult to work up a very fair day load, even in a small town which has blacksmith, machine shops, laundry, printing offices, dentists, grocers, butchers, restaurants, livery stables and numerous others who could use small power to advantage. Very many towns have one or two mills of considerable size which can be secured as customers. City pumping, in towns where there is a standpipe or reservoir, is very attractive, for this work can be usually done when the load is smallest, which is the time you may need the most exhaust steam for your heating purposes. In our case several industries located in town for the very reason that electric power was available at all hours at a reasonable rate.

When soliciting prospective customers it is just as well not to lay too much stress on cheapness, but rather to enlarge upon the fact that you will be able to furnish them much better and more convenient service than they can secure in any other way, as a motor can be located in the most convenient place, and will not be a source of annoyance by causing dirt, heat or noise, and the customer only pays for the actual power used.

It is also advisable to make some arrangement with a responsible company to handle their motors. You are then in a position to go to your customer and quote him a price for the motor installed complete. You are very much handicapped unless you do this, for you may tell your customer that you will furnish him with power at a rate which may be perfectly satisfactory to him. He will write to different parties for prices on motors, and then his troubles will begin, and it is ten to one that he will become disgusted and drop everything.

By making arrangements with some manufacturer you can install the motor for a sum that will cover the cost of motor and necessary labor and still give your customer a lower price than any respectable manufacturer will quote him, and furthermore, you will have the advantage of standardizing your motors, which permits you to change them in case of accidents, and your repair men soon become familiar with the construction of the machines, which you will find prevents many accidents and facilitates repairs.

During the past year we have installed 34 motors, ranging from ¼ to 5-horse power, which with one 85-horse power motor driving a mill 24 hours per day and one 45-horse power motor doing city pumping gives us an average day load of 150-horse power.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

MR. ARTHUR R. CRUSE, President of the Cruse-Kemper Company, of Philadelphia, writing under date of the 10th inst., says that the additions to the Company's plant at Ambler, Pa., are well underway, and it is fully expected that the buildings will be completed, fully equipped and in good running order by the 15th prox. It is also of interest to know that the Company has booked several orders in the line of purifier construction, and that it is under contract to construct a telescopic holder for the Marlboro (Mass.) Company. This holder is to rest in a steel tank, and its capacity is 150,000 cubic feet.

MR. PHILIP ALLEN, formerly a large owner in the Central Union Gas Company, of this city—in fact we believe he at one time was Secretary of the Central Gas Company, which Company was the predecessor of the Central Union—died in this city last Sunday. He was in his 50th year.

THE Capital City Gas Company, of Montpelier, Vt., has chosen the following executive management: Directors, J. Warren Lamb, A. C. Blanchard, Fred. Blanchard, George L. Blanchard and E. H. Dewitt; President, J. W. Lamb; Vice-President, A. C. Blanchard; Clerk and Treasurer, F. N. Smith; Superintendent, Benj. P. Bill.

THE residents of Fort Wayne, Ind., are now paying 25 cents per 1,000 cubic feet for natural gas. The service has been placed on a meter basis.

THE executive management of the Waynesburg (Pa.) Home Gas Company, as named at its last meeting, is: President, Jesse L. Ross; Vice-President, T. J. Wisecarver; Treasurer, M. R. Carver; Secretary, J. E. Debolt.

"F. R. P.," writing from Dayton, O., under date of the 10th inst., incloses the following: "On the 27th ult., Mr. Robt. R. Dickey, Sr.,

was confronted by his 87th birthday recurrence. He was born about 2 miles from Middletown, Butler county, O., October 26, 1816. He is a Buckeye born and bred, and has been identified with public works and large operations of a business character throughout his entire eventful life. Few residents of Ohio, now living, can compare with our highly respected citizen, in long identity with business life. To-day, as President of the Dayton Gas Light and Coke Company, he is a part of its active and most extended operations. Mr. Dickey is a most remarkable man, and his life furnishes a bright lesson to the young. His first business venture was as a bit of a boy, to be employed in a brick yard at the enormous sum of 18 cents per day, and that too, from early dawn to night. He was brought up on a farm, but thus early he started out for himself, with that will and energy which have made his long life a success. His father, Adam Dickey, came from Ireland as a boy, settled in Connellsville, Pa., and died in Butler county, at the age of 60. His mother, Mary Dickey, died at the age of 73. Longevity belongs to a period beyond them. Mr. R. R. Dickey, Sr., endured many hardships in early life, in connection with canal construction, with which he was early identified. He was present when the first ground was broken for the canals of Ohio. On this occasion, DeWitt Clinton, Governor of New York, came out to assist in its celebration, Mr. Morrow being then Governor of Ohio. It was a great event in Ohio's early history. In 1853, Mr. Dickey became a Director of the Dayton Gas Light and Coke Company. Samuel B. Brown was then President. Soon after, Mr. William Dickey, a brother of R. R., bought out Mr. Brown, and was made President. Mr. R. R. Dickey, Sr., succeeded his brother as President of the Company, and is such to-day. In the history of Dayton no Company nor organization has had a more successful and gradual growth. Indeed, Ohio presents no greater example in comparison. When Mr. Dickey became connected with this Company, there were about 300 consumers—to-day it numbers near 10,000. Growing, still growing and increasing—no new development escapes the attention of the Company, and its plant is to-day one of the most modern in the Central West. Hale and hearty, with unusual vigor and bespeaking many more years, Mr. R. R. Dickey, Sr. presides over this magnificent organization, a credit to the city and State, and a monument to his wonderful business career. The social side of Mr. Dickey should be mentioned in any sketch of his eventful life. Always cheerful, ever kind and generous, he has a cheery word for all who enjoy his acquaintance. No other man in Dayton stands higher in the respect of its people. It may well be said of him that he is always a gentleman in its truest and highest sense."—H.

MR. T. F. CLOHESY has been appointed Manager of the gas and electric properties at Quincy, Ills. Mr. J. C. Sloan leaves Quincy to assume the management of the Port Huron (Mich.) Company's plant. In connection with the gas and electric situation at Quincy, Ills., the Quincy Gas and Electric Company has issued the following circular: "On August 1, 1903, this Company sent to its patrons a circular in which it promised to its patrons that when the Independent Light and Power Company had actually begun operating its plant, that this Company intended to sell electric current to its patrons at a less price than its competitor was selling the same, regardless of the loss caused to this Company. As the Independent Electric Light and Power Company has commenced furnishing current, this Company intends to carry out its former promise and it, therefore, gives notice to its patrons and all other consumers that hereafter it will furnish electric current at a rate of 5 cents per 1,000 watts. This will apply to consumers who may have a contract with it at a higher rate as to those who have no contract at all. This Company further assures its patrons and all consumers of electric current that it intends to meet any price made by its competitor, however low."

MR. MATTHEW HENNEBERY, one of the original owners of the Peoria (Ills.) Gas Light Company, died in Peoria, the 4th inst. He was in his 60th year.

THE Laclede Gas Light Company, of St. Louis, Mo., is ready to receive proposals for its entire surplus of coke, for 1, 2 or 3 years, from January 1, 1904. Proposals may be made to the Secretary of the Company, and the output will average 30,000 tons annually.

THE Queens Borough Gas and Electric Company, of Far Rockaway, L. I., will construct a storage holder, up to 500,000 cubic feet capacity, on its plant at Rockaway Beach.

THE Brooklyn Union Gas Company, of Brooklyn, N. Y., has declared its regular quarterly dividend of 2 per cent. It is payable on the 1st prox.

THE extensions and improvements to the plant of the Wallingford (Conn.) Gas Light Company are being made under the direction of Mr. Frank D. Moses, of Trenton, N. J.

A CORRESPONDENT in Louisville, Ky., writing under date of the 8th inst., says: "The effect of a decision by Judge Toney yesterday in the case of Rowan Hardin against the Kentucky Heating Company amounts to a victory for the Louisville Gas Company in the long standing legal controversy between those two corporations. Mr. Hardin attempted to burn the mixed and manufactured gas of the Kentucky Heating Company in his residence for lighting purposes. This occurred shortly after the Court of Appeals had decided that the Kentucky Heating Company could not sell manufactured gas for lighting purposes on account of violating the charter of the Louisville Gas Company, which vests the latter Company with the exclusive privilege to carry on that business. In obedience to the Court of Appeals' mandate the Kentucky Heating Company shut off Mr. Hardin's gas which he was receiving from its pipes for lighting purposes. Mr. Hardin immediately instituted injunction proceedings against the Kentucky Heating Company to prevent it from cutting off his gas. Mr. Hardin contended that the manufactured gas which he bought from the Kentucky Heating Company was made by that Company for heating purposes, that his personal rights which could not be affected by any decision of the Court of Appeals, gave him the power to utilize a certain patent burner and thereby manufacture the heating gas into illuminating gas Both the Kentucky Heating Company and the Louisville Gas Company entered demurrers to this petition and were sustained in full by Judge Toney. In deciding the case he held that to grant Mr. Hardin's injunction would be in direct violation of the decision of the Court of Appeals, which said that the Kentucky Heating Company did not have the right to sell any kind of manufactured gas for lighting purposes. A decision in favor of Mr. Hardin would have brought the question up in a form favorable to the Kentucky Heating Company and reopened the litigation along that line."

A CORRESPONDENT in Detroit, Mich., writing under date of the 7th inst., says: "The Albion (Mich.) Gas and Coke Company has had a prosperous year, and has by an enterprising extension policy immensely strengthened its popularity with Albion light and fuel consumers. The Company has spent since reorganization a year ago, no less than $20,000 in improvements, including the enlargement of the works, laying of new mains and the addition of service pipes. Of the latter they have installed 165. The Company has sold 120 gas ranges, taken up 1½ miles of small pipe, and since April of this year has put down 4 miles of large pipe. An important contract has been closed with F. W. Schumacher for an addition to the retort house and purifying house structures. Next year the Company will install a large exhauster to replace the present one, a new bench of sixes; also a large scrubber and condenser."

MR. C. E. BURROWS, of Walla Walla, Wash., and Mr. Charles B. Hurley, of Tacoma, have applied to the authorities of North Yakima, Wash., for the right to there construct and operate a gas works.

MR. A. R. BURR has been appointed Sales' Agent for the New Haven (Conn.) Gas Light Company. He was formerly with the Miner, Read & Garrette Company, of New Haven.

ACCORDING to the Brooklyn (N. Y.) *Daily Eagle*, the authorities of Rockville Center, L. I., granted on the 2d inst., to the Nassau County Gas Company, of which Martin V. Wood is President, the right to lay, maintain, operate and extend its gas mains and pipes within the village limits for a term of 50 years. J. W. Gerety of the Citizens Gas Company, of Freeport, asked for a delay of 2 weeks, when he would be prepared to submit a proposition to operate the water and light systems at a saving of $1,000 a year in the present cost of maintaining the water and light plants. The franchise was granted under these conditions: The Company will be allowed to construct, maintain, operate and extend its pipe lines along and under all streets, avenues and all public places within the incorporated village of Rockville Center; that the laying of pipes under such highways shall not interfere with the public travel on such highways as the Company may see fit to use, and all excavating, etc., shall be under the supervision of the Board of Trustees; the surface and gutters of any streets shall be immediately restored to their natural grade upon the completion of the work, and when any opening is made on any street it shall be properly protected by the Company; the

(*Continued on page* 774.)

THE AMERICAN GAS LIGHT JOURNAL

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NOTIFICATION RESPECTING ADVERTISING.

Orders for new advertising, or for changes in standing advertisements, to insure attention in the issue following their reception, must be in hand any time of Wednesday.

AGENTS:

New York—American News Co., 39 and 41 Chambers St.
Germany—Lemcke & Buechner, of New York.
England—Aug. Siegle, 30 Lime Street, London.

MONDAY, NOVEMBER 16, 1903.

(*Concluded from page* 733.)

Company shall file with the Clerk of the village a bond of $10,000, with good and sufficient sureties, to be approved by the Board, guaranteeing that the Company will live up to its contract; also at the end of each year file a certified statement of the gross receipts of the Company signed by the President, Secretary and Treasurer of the Company; that the minimum rate of gross receipts upon which 5 per cent. be paid be fixed at $10,000 a year until the receipts exceed that amount; that the Company at the time of filing the acceptance of the franchise shall pay to the Treasurer of the village the sum of $500, which shall be on account of the percentage of gross receipts on the first year of the term of this franchise. The introduction of gas into Rockville Center is a step forward and one which Freeport has been debating for some weeks, notwithstanding a large number of residents desire the commodity and signed petitions for it."

Iron Age says that it has been announced that the Dominion Coal Company have in contemplation plans for a stupendous increase in the coal output from their colleries within the next 2 or 3 years, which will mean increased shipping facilities and an improved transportation service. It is said that this is the mission President Ross, who is accompanied by Austin King of Philadelphia, is on. Mr. Ross and Mr. King have been in consultation with the head local officials of the Company ever since their arrival. It is proposed to open 2 or 3 more mines to be operated through slopes, and equip the present ones with new machinery and new appliances for an increase. When these improvements are effected Mr. Ross expects to increase the output from 3,000,000 tons a year to 4,500,000 tons, and this will be gradually increased until it is brought up to the 5,000,000 mark. Operations looking forward to these developments will be begun early next year. They will mean that the employees will be increased to 7,000, and that the yearly wage list will be increased to $5,000,000. The Company will charter a fleet of steamers and cater to the home, American and European markets.

The Market for Gas Securities.

There is very little to report in connection with the ups-and-downs in Consolidated trading for the week, especially remembering the fact that not over 300 shares therein actually changed hands. The closing quotations for it to-day (Friday) was 175½ to 177. It might be, though, that a certain house of Hebrews, when it comes to covering, will find that buzz saws can cut. New York city gas bonds are becoming scarcer.

The point of the week, in connection with Greater New York gas securities, came from the borough of Brooklyn, in which charming suburban locality the Brooklyn Union Gas Company does business. Its Directors are considering some sort of stock readjustment, which to us looks like a capitalization of earnings preparatory to its absorbment by the Consolidated Gas Company. Those on the inside think that the first flash will be an increase in its indebtedness amounting to the third of its capital stock—the increase, of course, being $5,000,000—for which holders of record are to pay pat. That should be an inviting proposition. Keep your check books open when actual Brooklyn Union is offered for sale. Peoples, of Chicago, is 92¼ bid, ex div. Baltimore Consolidated is 62½ to 63, and Washington (D. C.) gas is nominally 290 to 295.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

NOVEMBER 16.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$73,177,000	100	175½	177
Central Union, Bonds, 5's	3,000,000	1,000	104	106
Equitable Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	118	120
Metropolitan	658,000	..	108	112
Mutual	3,500,000	100	280	295
Municipal Bonds	750,000	..	..	..
New Amsterdam Gas Co..				
Bonds, 5's	11,000,000	1,000	103	105
Northern Union, Bonds, 5's.	1,250,000	1,000	105	106½
New York and East River				
Bonds 1st 5's	3,500,000	1,000	108	108
" 1st Con. 5's	1,500,000	..	109	111
Standard	5,000,000	100	135	140
Preferred	5,000,000	100	155	170
Bonds, 1st Mortgage, 5's	1,500,000	1,000	116	117
Yonkers	299,650	500	130	..
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	188	200x
" " Bonds (5's)	15 000,000	1,000	119	119½
Bay State	50,000,000	50	⅛	¼
" Income Bonds	2,000,000	1,000	.	75
Binghamton Gas Works	450,000	100	28	30
" 1st Mtg. 5's	500,000	1,000	93	96
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	4	5
" " Bonds, 5's	5,256,000	1,000	73	76
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Cincinnati Gas & Elec. Co..	29,500,000	100	92¼	92½
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	101	101½
Columbus (O.) Gas Lt. & Heating Co	1,682,750	100	88¼	89¼
Preferred	3,026,500	100	107½	109
Consumers, Jersey City Bonds	600,000	1,000	100	102
Consumers, Toronto	1,700,000	50	218	225
Consolidated, Baltimore	11,000,000	100	62½	63
Mortgage, 6's	3,600,000	..	..	118
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490 000	..	..	112
Consolidated Gas Co. of N.J.	1,000,000	100	15	17
" Con. Mtg. 5's	880,000	1,000	86	90
Consolidated G. & E. Co.'s.				
Little Falls, N.Y.	90,000	100	..	100
Bonds	75,000	..	..	100
Detroit City Gas Co.	4,825,500	50	87	95
" Prior Lien 5's	5,603,000	1,000	99½	100
Detroit Gas Co., 5's	381,000	1,000	77	79
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	39	40
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	25	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104½	105
Hartford	750,000	25	245	265
Hudson County Gas Co., of New Jersey	10,500,000	..	25	..
" Bonds, 5's	10,500,000	..	101	103
Indianapolis	2,000,000	..	50	65
" Bonds, 6's	2,650,000	..	103½	106½
Jackson Gas Co	250,000	50	73	75
" 1st Mtg. 5's	290,000	1,000	101	102½
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,822,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	79	90
Preferred	2,500,000	100	90	..
Bonds	10,000,000	1,000	109½	110
Lafayette Gas Co., Ind.	1,000,000	100	..	60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	130	140
Madison Gas & Elec. Co.				
" 1st Mtg. 6's	350,000	1,000	107½	108½
" 6 per cent. scrip, due 1910	100,000	25	85	87
Montreal, Canada	2,000,000	100	218	184¾
Nashville Gas Lt. Co.	1,000,000	100	110	..
Newark, N. J., Con. Gas Co.	6,000,000	..	56	58
Bonds, 6's	4,600,000	..	105	105¾
New Haven	1,000,000	25	250	..
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	92¼	92¼x
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,000	1,000	..	..
2d "	2,500,000	1,000	104	..
Rochester Gas & Elec. Co..	2,150,000	50	88	..
Preferred	2,150,000	50	118	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	15,800,000	100	67	67¼
St. Joseph Gas Co.				
" 1st Mtg. 5's	751,000	1,000	92	94½
St. Paul Gas Light Co.	1,500,000	100	45	47
1st Mortgage 6's	650,000	1,000	113	116
Extension, 6's	600,000	1,000	112½	115
General Mortgage, 5's	2,465,000	1,000	92	93
Syracuse, N. Y.	1,975,000	100	46	48
Bonds	2,047,000	1,000	94	96
Washington, D. C	2,600,000	20	290	295
First mortgage 6's	600,000	..	..	..
Western, Milwaukee	4,000,000	.	..	..
Wilmington, Del.	600,000	50	282	..

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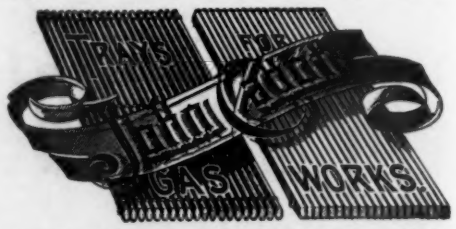

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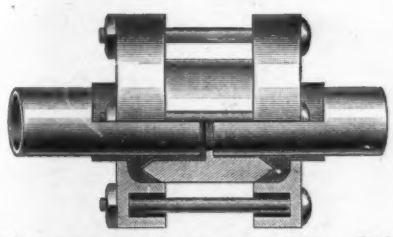

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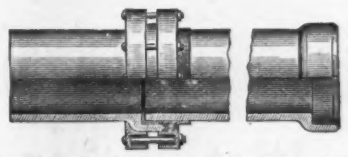

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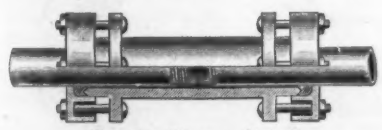
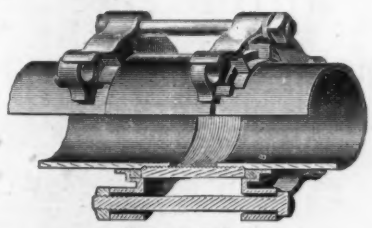
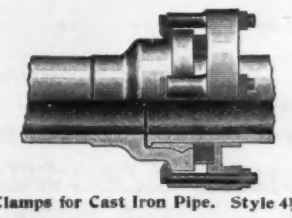


Regular Sleeve. Style 2.



Clamp. Style 4.



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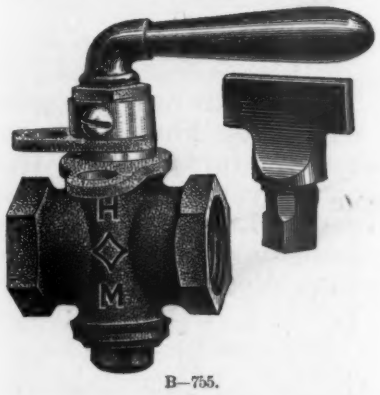

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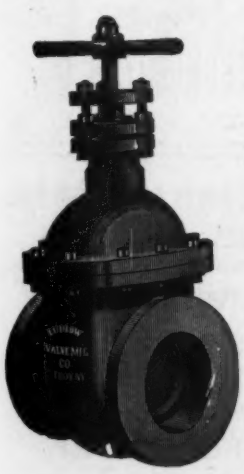
TROY, N. Y., U. S. A.



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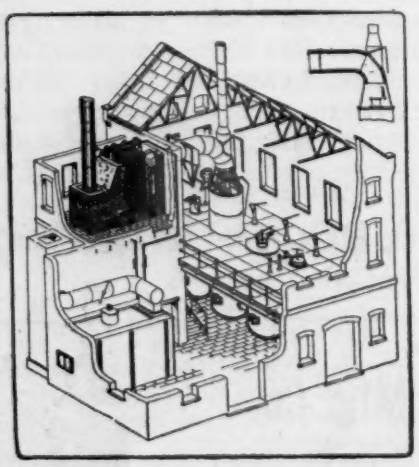

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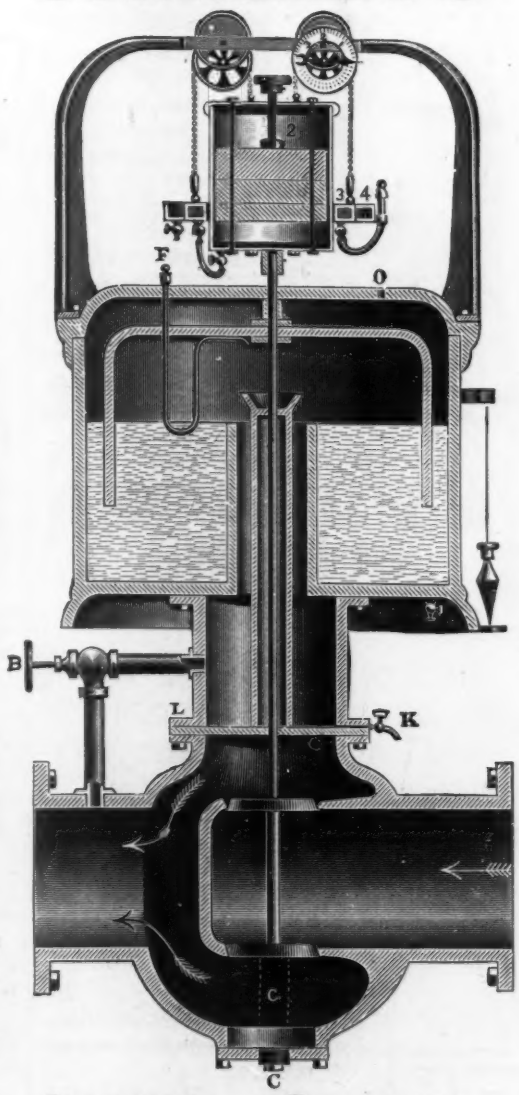

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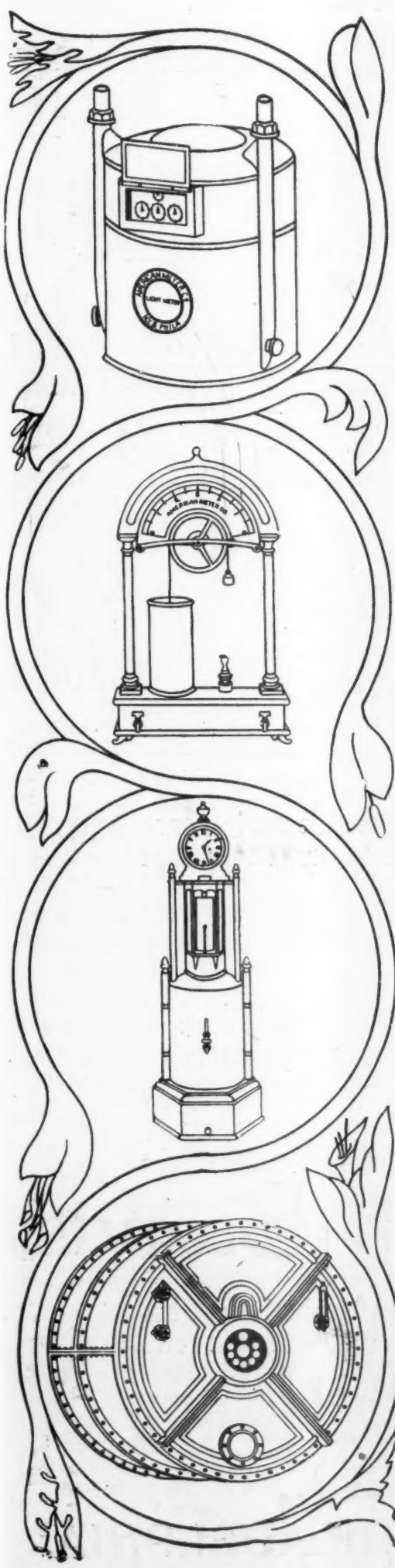
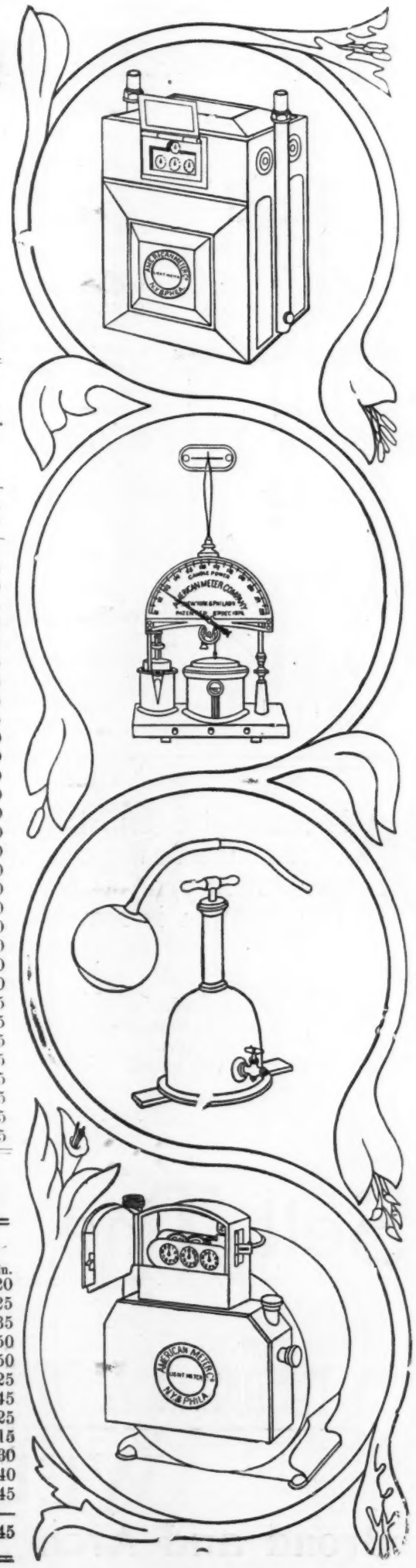




PUBLIC LIGHTING TABLE.

DECEMBER, 1903.

Day of Week.	Date	Table No. 1. FOLLOWING THE MOON. Light.	Extingnish.	Table No. 2. NEW YORK CITY. ALL NIGHT LIGHTING. Light.	Extinguish.
				P.M.	A.M.
Tue.	1	3.30 AM	6.00 AM	4.20	6.10
Wed.	2	4.30	6.00	4.20	6.10
Thu.	3	No L.	No L.	4.20	6.15
Fri.	4	No L. FM	No L.	4.20	6.15
Sat.	5	No L.	No L.	4.20	6.15
Sun.	6	5.00 PM	8.00 PM	4.20	6.15
Mon.	7	5.00	9.00	4.20	6.15
Tue.	8	5.00	10.10	4.20	6.15
Wed.	9	5.00	11.20	4.20	6.15
Thu.	10	5.00 LQ	12.30 AM	4.20	6.20
Fri.	11	5.00	1.40	4.20	6.20
Sat.	12	5.00	2.40	4.20	6.20
Sun.	13	5.00	3.40	4.20	6.20
Mon.	14	5.00	4.50	4.20	6.20
Tue.	15	5.00	6.20	4.20	6.20
Wed.	16	5.00	6.20	4.20	6.20
Thu.	17	5.00	6.20	4.20	6.20
Fri.	18	5.00 NM	6.20	4.20	6.20
Sat.	19	5.00	6.20	4.20	6.20
Sun.	20	5.10	6.20	4.20	6.20
Mon.	21	5.10	6.20	4.20	6.20
Tue.	22	5.10	6.20	4.20	6.20
Wed	23	8.20	6.20	4.20	6.20
Thu.	24	9.10	6.20	4.20	6.25
Fri.	25	10.10	6.20	4.20	6.25
Sat.	26	11.10 FQ	6.20	4.20	6.25
Sun.	27	12.10 AM	6.20	4.20	6.25
Mon.	28	1.10	6.20	4.20	6.25
Tue.	29	2.10	6.20	4.20	6.25
Wed.	30	3.10	6.20	4.20	6.25
Thu.	31	4.20	6.20	4.20	6.25

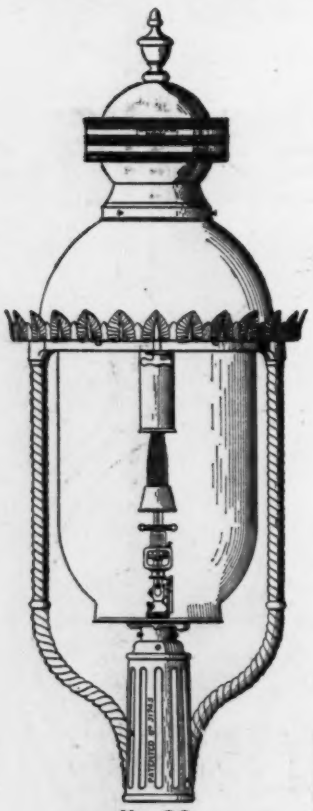
TOTAL HOURS LIGHTING DURING 1903.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	245.00	January	423.20
February	192.00	February	355.25
March	201.00	March	355.35
April	167.20	April	298.50
May	152.00	May	264.50
June	131.00	June	234.25
July	140.40	July	243.45
August	156.20	August	280.25
September	171.20	September	321.15
October	198.20	October	374.30
November	216.30	November	401.40
December	232.10	December	433.45
Total, yr.	2203.40	Total, yr.	3987.45

NEW YORK, 33 Nassau Street. PHILADELPHIA, Broad and Arch Streets. CHICAGO, Foot of Orleans Street. BOSTON, 814 Beacon Building.
CLEVELAND, 809 Cuyahoga Building. ST. LOUIS, 712 Roe Building. SAN FRANCISCO, 712 Polk Street.

WELSBACH STREET LIGHTING COMPANY

.... OF AMERICA ....



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The imitation stuff is bad for the customer---which is bad for you.

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Chicago, Ills.	**Lynn, Mass.**	**New York** (Central Union Co.)
Amesbury, Mass.	**Newark, N. J.**	**Cicero, Ills.**
Aberdeen, S. D.	**Washington, D. C.**	**Chicago** (Ogden Co.)
Winsted, Conn.	**Boone, Ia.**	**Easton, Pa.**
Canon City, Col.	**Pueblo, Col.**	**Lawrence, Mass.**
Schenectady, N. Y.	**Charlotte, N. C.**	**Council Bluffs, Ia.**
Hagerstown, Pa.	**Fall River, Mass.**	**Chattanooga, Tenn.**
Malden, Mass.	**Duluth, Minn.**	**Tuckerton, N. J.**
Bridgeport, Conn.	**New York** (Mutual Co.)	**Springfield, O.**
Albert Lea, Minn.	**Waltham, Mass.**	**Easton, Pa.** (2d contract).
Brooklyn, N. Y.	**Dover, Del.**	**Mobile, Ala.**

TOTAL DAILY SETS TO OCTOBER 15, 1903, ... 55
TOTAL DAILY CAPACITY, ... 56,600,000 cubic feet.
TOTAL SETS TO DATE, ... 502
TOTAL DAILY CAPACITY, ... 356,280,090 cubic feet.

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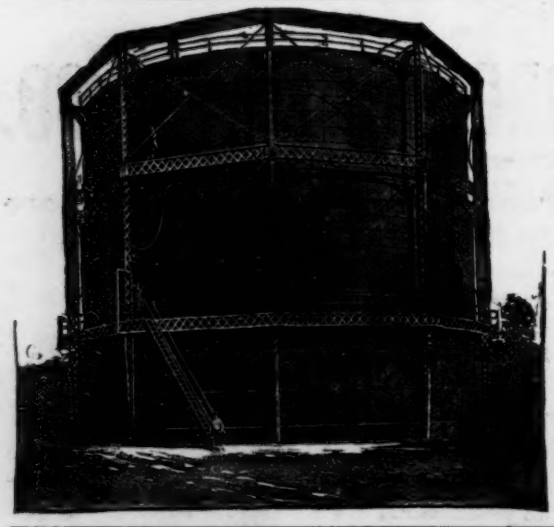

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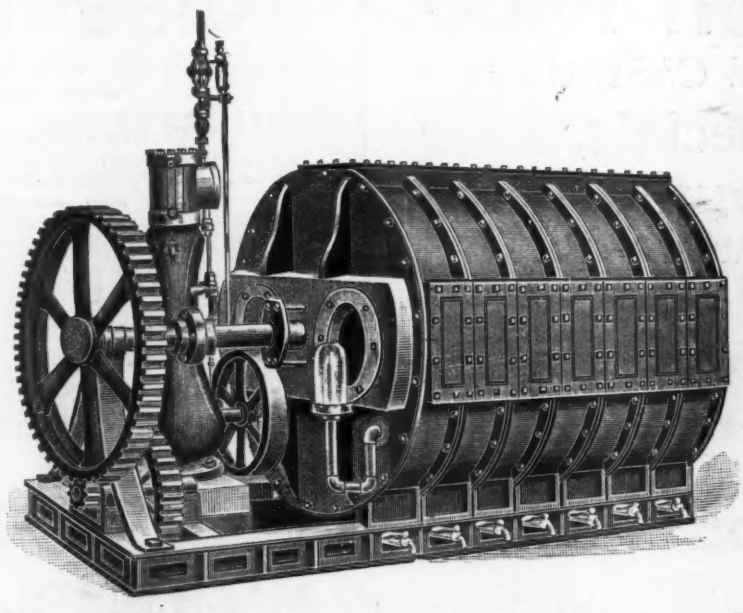

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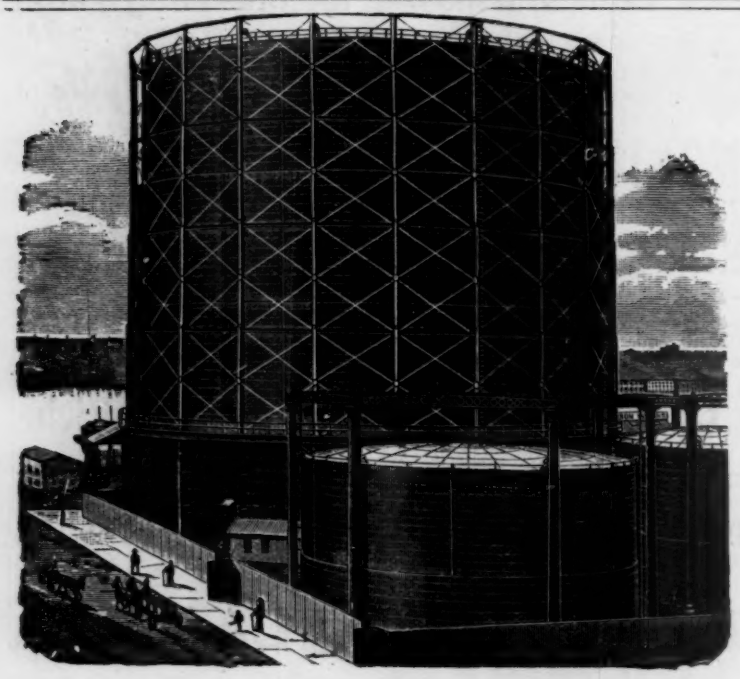

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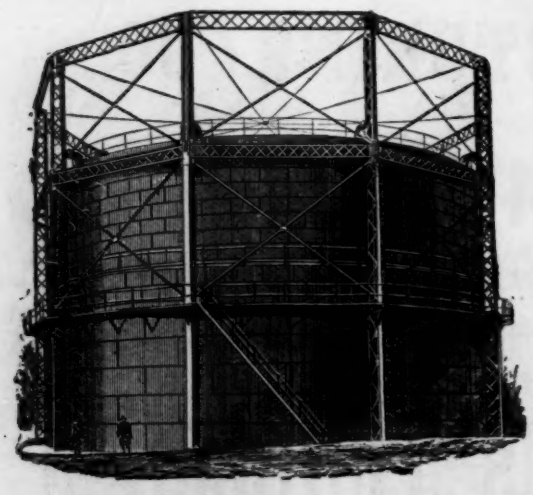

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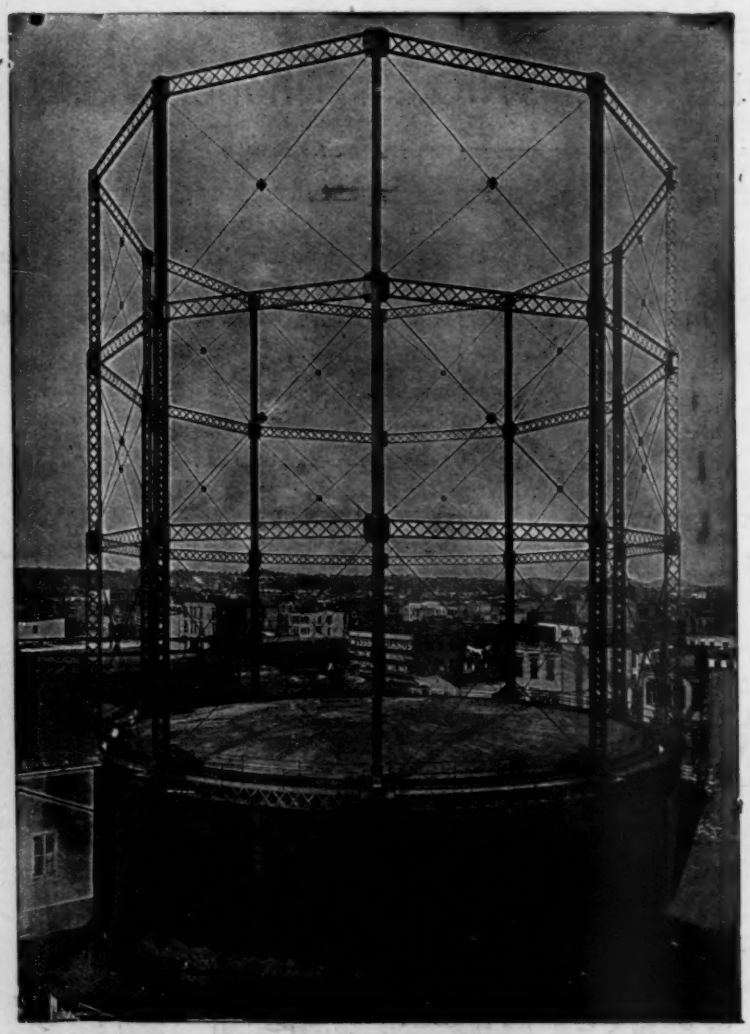

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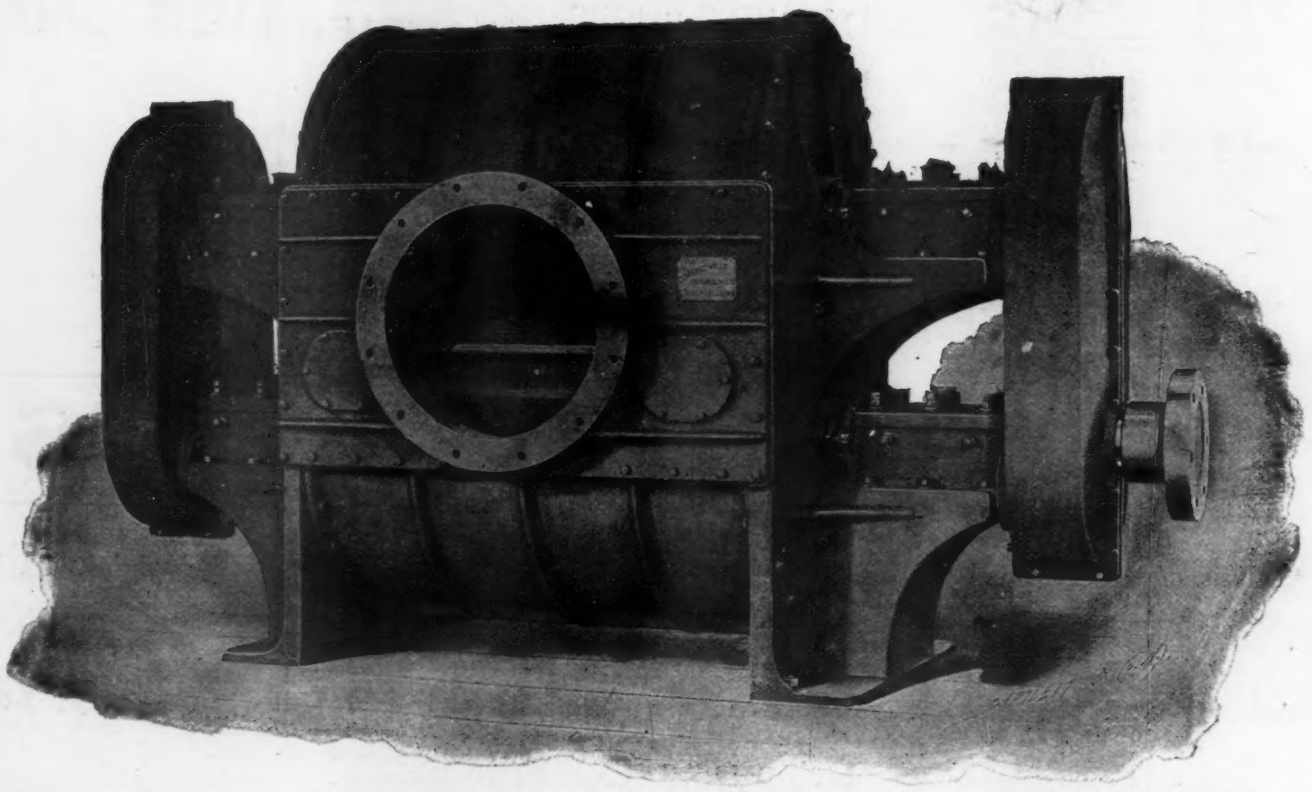

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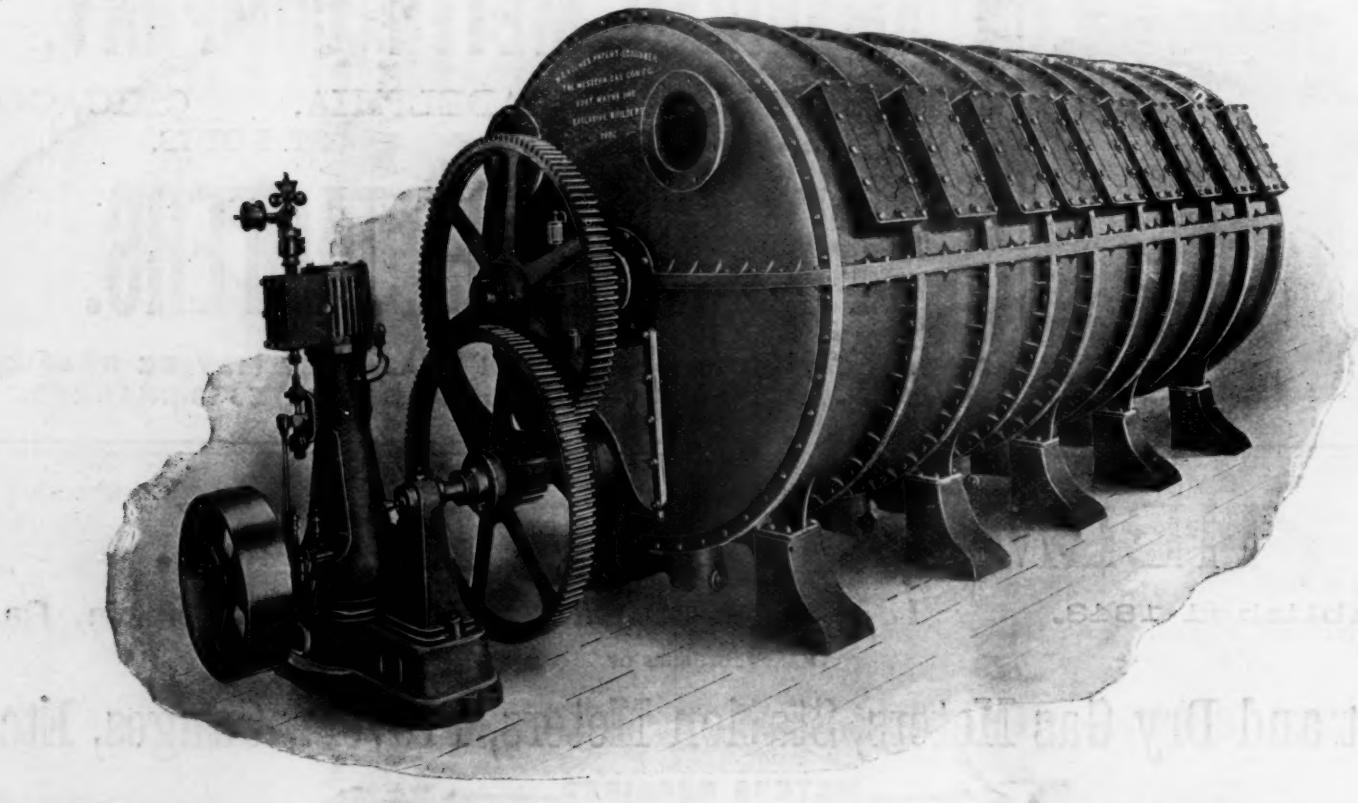

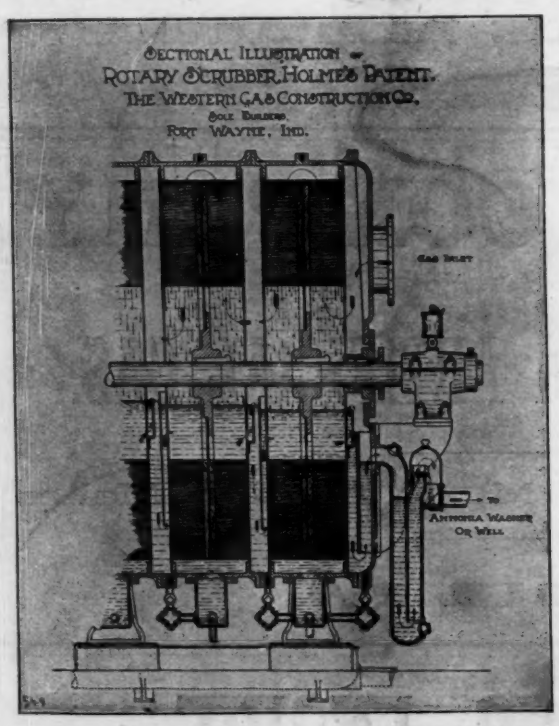

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